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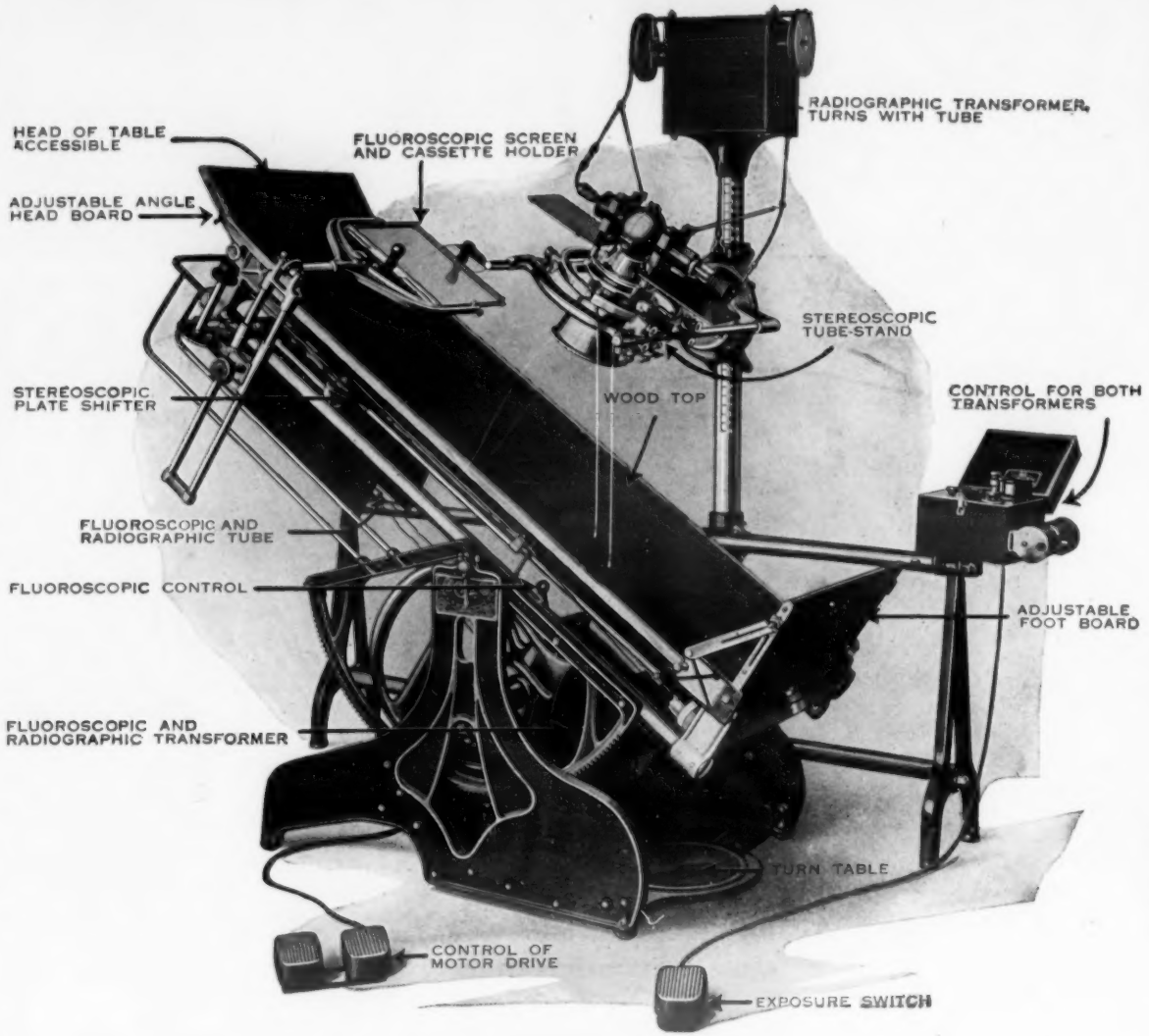

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THE AMERICAN JOURNAL OF ROENTGENOLOGY

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THE MODE OF RADIATION UPON CARCINOMA*

BY JAMES EWING, M.D.

Professor of Pathology, Cornell University Medical College, New York City

THE early observations of the effects of radium and roentgen rays upon carcinoma disclosed a certain specific effect of these agents upon many tumor tissues, in the sense that much smaller doses were required to induce degeneration and disappearance of tumor tissues than of normal tissues. Information derived from clinical and experimental sources led to the conclusion, adopted by many, that tumor tissues were from four to eight times as susceptible as normal tissues; but it cannot be said that these figures represented anything more than a careful estimate, since they involved factors which were not susceptible of accurate physical measurements.

Increasing experience soon disclosed, however, that there is a marked but usually not extreme variation in the reaction of the skin in different subjects, and gradually it has become apparent that the different organs exhibit different grades of susceptibility to radiation, not only as regards their structural integrity, but especially as measured by the resulting functional disturbance. Thus the skin is far more resistant than the buccal mucosa, which itself resists far more than the rectal mucosa. I find recurring evidence that the bladder mucosa is notably susceptible to radiation. Brain tissue has revealed itself as unexpectedly resistant both in structure and function. Normal lymphatic tissue I have repeatedly found to be surprisingly unaffected by heavy external radiation which had completely inhibited or largely destroyed the growth of invading squamous cancer, while inflammatory, granulomatous, and neoplastic overgrowths of lymphatic tissue melt down rapidly.

The experienced radiologist learns to take careful account of the susceptibility of the normal tissues that may be exposed to radiation in the course of treatment, and to vary the dosage accordingly. Age, also, is an important factor in determining the reaction of normal tissues, the susceptibility diminishing with increasing age.

Comparatively little attention has been paid to the effect of associated pathological conditions, but it is obvious that such conditions may be of great importance. Anyone accustomed to examining sections of human tissues under the microscope, is not surprised to find pronounced grades of vascular lesions, arteriosclerotic or luetic, in organs and tissues where their presence was unsuspected. I have little doubt that such associated alterations of structure have been responsible for many anomalous results of radiation which surprise and disturb the operator. Such tissue lesions are so common after forty years of age that they should always be sought out and demonstrated if possible, and taken into account in calculating the resistance of normal tissues to radiation. Disturbances of circulation such as result from anemia or cardiac diseases, as well as disturbances of the temperature must also

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 26–28, 1922.

be considered as affecting the reaction of tissues to radiation, but very few data regarding their influence are available.

Now while these considerations do not alter the fact that in general the different tissues maintain within certain limits a uniform reaction to radiation, they are sufficient to show that anything like a uniform standard reaction of the tissues does not exist. On the contrary, they compel the conclusion that the different tissues behave in a rather variable manner toward radiation, and that this behavior may be greatly altered by previous structural changes and other pathological conditions. Therefore the radiologist must deal with the question of dosage as regards normal tissues, not from the standpoint of pure physics, but rather from a broad, alert, and strictly medical point of view. These considerations seem to me especially pertinent when they concern the state of the tissues immediately adjacent to a tumor that is to be radiated, since upon the reaction of such adjacent tissues the result of the radiation will largely depend.

Considering the reaction of tumor tissues to radiation one finds remarkably wide variations in their behavior, some of which could hardly be predicated on previous knowledge of their structure and physiology. Indeed it may almost be said that the first principle of radiotherapy is the variability of different tumor tissues to radiation. With increasing experience we are able with considerable assurance to arrange the different tumors in series according to their susceptibility. Some of them, like neurofibrosarcoma seem almost, if not quite, as resistant as any normal tissue. Others like hornifying squamous carcinoma are very resistant, yield immediately only to the caustic action of radium or soft roentgen rays, and slowly lose their growth capacity only after repeated heavy dosage of hard rays. Some embryonal tumors, that is, those derived from cells which have never fully differentiated, such as the numerous group of basal cell carcinomas, probably deserve the next position, being relatively susceptible, requiring rather strong dosage, but receding as a rule under a radiation that does not injure the surrounding normal structures. An intermediate position also is occupied by many benign or relatively benign tumors, as myoma, angioma, adenoma, and adenocarcinoma. There is much variation in this group, but in general they require vigorous treatment, respond only to strong or repeated dosage, recede slowly, and finally yield their vitality reluctantly, if at all. The therapeutic goal varies with many complicating circumstances, and each case becomes a study in itself.

The cellular, anaplastic, clinically highly malignant, rapidly growing and disseminating tumors, derived from previously adult cells, are generally very susceptible to all forms of radiation. Upon this demonstration is based the belief that all such tumors are better treated by radiation than by attempts at removal, although on account of their rapid dissemination the prognosis is always unfavorable. This group includes diffuse carcinoma of the breast, stomach, and other organs, and many forms of sarcomas. Of equal susceptibility are the various cellular carcinomas of the testis, but this organ gives origin to many relatively adult teratomas which are quite resistant. There is no better illustration of the necessity of accurate knowledge by the radiologist of the structure of tumors, and of the great variations in structure among tumors of a closely related group, than is found with testicular growths. The surgeon can remove from the scrotum with equal facility a chondro-adenocarcinoma or a round cell carcinoma, but the radiologist will be completely blocked when he finds the chondro-adenoma quite resistant while the carcinoma melts away rapidly, and he will be further mystified when he sees the shrunken carcinoma promptly recur in the abdomen, while the resistant chondro-adenoma, its epithelial structure rendered inactive, gradually recedes and gives no further trouble. The abdominal metastases of testicular tumors also vary greatly in structure and reaction. Some time ago I performed autopsies on the bodies of two cases of this type which had received heavy deep *x*-ray and radium therapy. One of them died with rapid collapse a few days after treatment with symptoms which were interpreted as *x*-ray

and radium intoxication. Examination disclosed a very large abdominal tumor, extensively necrotic, and containing about one quart of fluid blood lying in a central cystic cavity and throughout the tumor, from which the patient had bled to death. The radiation had caused collapse of the delicate vascular system with hemorrhagic infarction of the entire tumor.

In the other case the tumor had resisted all efforts to reduce its bulk, while the patient succumbed with edema of the lower half of the body. Autopsy showed that we had to deal with a highly fibrous tumor and that the cicatrization induced by the treatment had resulted in nearly complete occlusion of the aorta and vena cava. In the first case the very cellular tumor was of rapid growth; in the second it had grown slowly for several months.

These observations are of interest in view of the rapid development of deep high-voltage *x*-ray therapy. They indicate that unless the operator combines with his powerful physical machine a considerable knowledge of the pathological anatomy of tumors, he may have many surprises and disappointments, and may sometimes do more harm than good.

Most susceptible of all tumors is the lymphomatous group which usually recede rapidly under moderate dosage. Here may be grouped the cellular types of Hodgkin's granuloma, leukemia, lymphosarcoma, thymic tumors, and myeloma. Yet again it is necessary to recall that in some cases of Hodgkin's disease there is very marked proliferation of endothelial cells and much fibrosis, which are resistant to radiation, and that in late stages of all cases this resistance, due to structural peculiarities, is pronounced.

Certain general factors enter prominently into the question of tumor tissue resistance. It is believed that the dividing nucleus is more susceptible than the resting nucleus, and certain therapeutists have undertaken to fractionate the dose so as to catch the cells at their supposed periods of division. The results do not support the hypothesis, for increased resistance is generally encountered in such experiments. If one relied on attacking dividing cells to destroy a tumor, one would seldom succeed.

Richly and delicately vascularized tissues are invariably susceptible to radiation, while the striking decline in bulk often exaggerates the real effects of the dosage. Since the vascular supply of all cellular malignant tumors is very unstable, its disturbance is probably the chief mechanism in bringing about the destruction. Disturbance of a delicately balanced circulation has often been revealed as the modus operandi of many cancer cures, as well as of many spontaneous regressions.

On the other hand, the presence of much intercellular substance, especially if mucinous, fibrous, or hyaline, effectually prevents much decrease in bulk of radiated tumors. At this point I beg to warn most urgently against the common assumption that diminution in bulk is a reliable criterion of effective radiation, or increase in bulk a proof of growth. Often reduction in bulk means merely absorption of fluids, slowing of secretion, draining of cysts, or closure of vessels with central necrosis while peripheral cells remain intact.

In and about certain carcinomatous tumors which are increasing rapidly in bulk there is extensive infiltration by lymphocytes often associated with granulation tissue, both of which elements contribute largely to the bulk of the tumor. It is difficult to say whether this lymphocytic exudate is to be interpreted as a primary defense reaction or as a secondary result of the diffusion of chemotactic tumor proteins. Radiation will surely cause a sharp reduction in the bulk of such tumors, but whether the real therapeutic effect is equally pronounced seems much less certain. Whatever their source these lymphocytes certainly act as a barrier against the progress of the disease, and one may well question whether their destruction is a wise procedure. In such cases I should be much interested in attempting to treat the case after the plan suggested by Murphy,—by stimulating the production of more lymphocytes; but I am not aware that a local accumulation of lymphocytes can be secured by *x*-ray therapy.

Often the clinical observer is alarmed by increase of bulk following radiation and immediately concludes that the tumor is growing more rapidly. On such crude con-

ceptions are based most of the so-called stimulations of tumor growth by radiation. When a tumor swells following radiation it is generally due to hyperemia, swelling of tissue cells, and exudation of serum, blood, and leucocytes. In certain tumors mucinous degeneration follows treatment and causes a rapid uniform swelling. Hemorrhages have a similar effect. Bulky serous exudates are often revealed as the source of alarming increase in the size of radiated tumors. Most frequently in my experience it is bacterial infection that has occurred in the highly susceptible radiated tumor tissue and led to the erroneous assumption of increased growth. When all these sources of increased bulk are eliminated, little remains of the so-called stimulation of tumor growth by therapeutic radiation. I have never seen anything that could be clearly interpreted as the stimulation of tumor growth by radium or roentgen ray, and I have not been able to find any properly attested record of such an event.

It thus appears that the reaction of tumor tissues to radiation is extremely variable. This reaction depends on tumor structure, and since the structure of tumors is one of the most extensive and complex fields in pathology, it is obvious that the reaction of tumors to radiation must be equally complex. These conclusions have been fully borne out by clinical experience. They represent the main fruits of the close clinical study of the effects of radiation of the past decade, and they are of the first importance to the sound progress of radiologic therapy.

Nevertheless, in the face of this experience, won with much difficulty, and at the expense of much suffering and loss by our patients, we are confronted with the proposition that tumor dosage shall be standardized. It is proposed to establish a standard cancer dose and a standard sarcoma dose. Formulae prepared with mathematical accuracy in the physical laboratory are to replace the medical sense of the clinician, the principles of oncology, and the experience of the radiologist.

There is doubtless a broad field of research in the closer calculation of the various physical factors that enter into dosage. Much progress has been made along these lines, rendering physical therapy a comparatively safe and dependable method, which we gratefully credit mainly to the physicists. But the idea that anything approaching a uniform dosage can ever be established for all the various forms of cancer, or all the varieties of sarcoma, can be entertained only by those who deal with a few common types of cancer which they imperfectly observe, or by those whose work is confined to the experimental cancer laboratory. This attempt to substitute physics for biology and medicine can only prove an obstacle in the way of sound progress in radiotherapy.

The conception of a standard dosage seems to emanate mainly from the notion that radiation cures cancer by killing cancer cells. The idea is an inheritance of the old surgical point of view, that the cancer must be extirpated, root and branch. Thus the experimentalist places a fragment of cancer tissue in a dish, exposes it to radiation, transplants it back into an animal and calculates the killing dose when it fails to grow. This type of experimentation has a definite and somewhat important place, but as an adequate basis of clinical deductions it has seldom escaped criticism when presented before scientific bodies. It has repeatedly been pointed out that such experiments wholly fail to take account of the reaction of the living tissues, which is the main element in the selective cure of cancer by roentgen ray and radium. We are therefore compelled to review our knowledge of the mechanism of the action of these physical agents in causing the regression of cancer.

1. When a practitioner possessing a small amount of radium applies it to a rodent ulcer in repeated small doses over a period of weeks he usually observes the disappearance of the tumor and very often it never recurs. Meantime the skin shows little reaction and the scar is small or absent. Exactly what he has done no one knows, but he has not killed any cancer cells. Sections taken at intervals through tissue so treated, show hyperchromatism of nuclei and hydropic swelling of tumor cell bodies, followed by gradual atrophy of the cells. At the same time the surround-

ing tissues become active, leucocytes emigrate, lymphocytes and plasma cells appear, capillaries proliferate, and all these invade and replace the tumor mass. A slow regressive process with degeneration of tumor cells, and a progressive process with exudation and proliferation of normal tissues are set going, and as a result of these processes the tumor is cured.

2. When larger amounts of silver-filtered radium are inserted over a cervical carcinoma in sufficient dosage to effect a cure of a superficial lesion at one application, much the same course of events is observed. Some superficial tumor cells may suffer immediate necrosis, but tissue sections show that the bulk of the tumor is removed by a very rich exudate of lymphocytes and plasma cells, and by active growth of new capillaries which surround and compress much of the deeper parts and mechanically extrude the outer layers of the degenerating tumor cells. In many cases of this type I have failed to find many killed or necrotic cells, but have been able to trace all stages of the atrophy of degenerating tumor cells in the mass of reacting proliferating tissue. It is clear that the reaction of the tissues is an essential factor in the curative process. Under some circumstances, when this reaction fails, no amount of radiation succeeds in killing the tumor cells. I have seen recurrent rodent ulcer very heavily radiated, with necrotic stroma tissue supporting well stained and apparently viable tumor cells. Every radiologist is familiar with those indolent reactionless cancerous ulcers which resist all efforts at cure and have to be excised or burned out.

3. When radium emanation needles are inserted into a bulky squamous tongue cancer, a method which Regaud condemns as not true selective radium therapy, much tumor tissue is killed, but the cure, if it occurs, results from the more distant gamma ray effects which excite a wide tissue reaction and which render radium in this form the best caustic ever devised for cancer.

4. When deep bulky tumors are subjected to 2 gm. radium packs or penetrating roentgen rays, larger masses of tumor tissue may be killed, but not by the direct effects of the radiation. Almost always it will be found that the necrosis is due to occlusion of delicate blood-vessels, leading to anemic infarction and secondarily to death of tumor tissue. Direct killing of deep tumor cells is probably never accomplished by external radiation. It is an important law of pathology that necrosis of tissue cells usually results from failure of the circulation. This law has few exceptions in radiotherapy.

5. When a radium pack or deep roentgen rays act through the abdomen on a large uterine myoma, the myoma often disappears completely. The mechanism of this action is as obscure as it is surprising. Probably several factors are concerned, but the killing of the resistant muscle cells apparently plays no part. Tumors thus treated, become soft, cystic and flabby, and some appear to undergo anemic infarction with liquefaction necrosis. Others show mainly hyaline change with only partial atrophy. A primary effect on the blood-vessels is highly probable, but it may very well be that a temporary or permanent inhibition of the functions of the ovary acts indirectly in diminishing the nutrition and vitality of the tumor cells.

I have thus reviewed several of the more familiar conditions under which the curative action of roentgen ray and radium is observed. These do not exhaust the peculiar problems which confront the radiologist who proposes to secure nicely adjusted results by this, the first rational treatment of cancer ever devised. Yet in all of them the most detailed knowledge we possess indicates clearly that the curative action is not the result of a direct effect exclusively upon the tumor cells, but involves especially a peculiar reaction of the normal or invaded tissues. In this reaction are doubtless included many fundamental physiological properties of the tissues which, under the term "inflammation," have deeply engaged and invariably baffled the master-minds of medicine. We need a Virchow, a Waldeyer or a Weigert, to solve these riddles. None of these men, to whom we owe most of our knowledge of inflammation, ever saw the highly peculiar tissue reactions of radium. They are specific

and reveal hitherto unsuspected properties of irritated tissues.

Modern research has sought a clue in the chemical changes, the ferment actions, the vitamine content of radiated tissues, etc., but without definite results. Personally I am content to record in familiar morphological terms the histological changes observed in tumor cells and reacting tissues, fearing that here as elsewhere, ultimate knowledge of the nature of these processes, such as the chemist and the physicist boldly seek, will always be denied us. Moreover this simple morphological interpretation reveals the highly important fact that in treating cancer by physical agents we are not merely killing cancer cells, in the sense of the physicist, nor extirpating it entirely, according to the surgeon's plan, but rather are calling upon Nature's forces to accomplish the cure. On this account we may assert that physical therapy, although still lacking some essential elements of an ideal method, is to some extent a rational therapy of cancer so far as we know the disease.

If we may accept the results of certain experimental studies of lower animal cancer, then the absorption of tumor tissue within the body, such as follows radiation, is an additional feature of a rational therapy. For the most definite experimental evidence of artificial immunization against cancer has been secured from the regression of tumor tissue within the body. It has often been noted, as recently stated by Regaud, that extirpation of a primary tumor is often followed by immediate appearance of metastatic growths in lungs or elsewhere, suggesting that latent cell emboli were released from growth restraints by the extirpation of the primary tumor. The body seems capable of producing only so much tumor tissue at a time, and it is better to have it all at one point than scattered through the organs. From this point of view primary tumor tissue may be regarded as a safeguard, a noli me tangere, which the surgeon often removes with disastrous results, but which, when slowly absorbed under radiation, may yield some increased immunity to the body.

Whether or not these speculations are in any degree valid, it is certain that the rational and successful pursuit of radiation therapy calls for a thorough study of the mechanism by which physical agents affect neoplastic diseases. It is also obvious that the mechanism, being highly complex, is not mainly a matter for physical measurements, but involves many principles of physiology and pathology. The introduction of radiation therapy by forcing attention to these new phases of tissue reaction, and demanding a detailed knowledge of the symptoms, clinical course and pathology of tumors, has introduced a new era in the study of cancer.

Radiotherapy will progress more soundly if it follows the spirit of this era, avoids rigid procedures and blanket rules, and makes full use of the new knowledge which the development of this branch of medicine has both rendered necessary and placed at its disposal.

REPORT OF CASE OF EPITHELIOMA OF THE CORNEA*

BY D. Y. KEITH, M.D. AND J. P. KEITH, M.D.

LOUISVILLE, KENTUCKY

MALE, aged sixty-four. Family history negative for new growths, or tuberculous or luetic infection.

Patient has never had a severe illness except a malignant ulcer of the left temple seven or eight years ago, at the age of fifty-seven, which is described in detail as a footnote.[1]

Present History. Seven months ago he noticed a redness in his left eye which persisted for several days. As this redness began to disappear he noticed that his vision was gradually failing. Within sixty days' time it appeared to him as if he was in the moonshine during the day; he was unable to see well enough to chop wood, and could see only from the outer lower quadrant of the left eye. At about the three month period his family and friends began to notice that the eye was becoming of a milky color. When first seen by us the entire cornea was of a milky white or limestone color, being much denser over the inner and upper half of the cornea; the extreme lower outer quadrant near the limbus was of a much fainter density. The new growth was limited to the cornea with no extension to the bulbar conjunctiva. Sight was so much impaired that he could not recognize a bright light except when placed upon the floor or beneath the eye.

No section was removed for microscopical study. The diagnosis of an epithelioma of the cornea had been made clinically by Dr. J. C. Daniels and confirmed by Drs. C. T. Wolfe and A. O. Pfingst. All agreed that nothing could be done surgically except an enucleation of the eye, which they recommended done as early as possible, unless the patient wished to try one application of radium. This was urged by Dr. Daniels.

On March 30, 1921, after cocainization of the left eye, a self-retaining lid retractor was inserted and an application of 50 mgm. of radium unfiltered was applied to the nasal and to the temporal half of the left eye at a distance of 1 cm. A total of 42 mm., however, was applied to each side of the eye. No attempt was made to protect the lids. The radium was distributed in 4 gold needles of approximately 12½ mgm. of radium element each. The patient's local ophthalmologist, who saw him every few days, says the radium reaction in the cornea was hardly perceptible and was at its height at the end of the third week. On May 12, 1921, six weeks after the radium application, all the macroscopic evidence of the limestone color of the cornea had disappeared and it was difficult to detect which eye had been affected. He was last seen five months after the application of radium, with no evidence of return. His sight has been completely restored.[2]

As no microscopic diagnosis was made in this case, it may have been benign. The rapid growth to cover the entire cornea in seven months is against this view. There was no macroscopic involvement of the bulbar conjunctiva. Was this an epithelioma of the cornea, or should it be classed as a new growth of the cornea, probably benign in character? From the few brief descriptions of corneal growths obtainable we believe it to be malignant. There is no question of the malignancy of the left temple, described in a footnote.

We believe this case teaches us that the

[1] In September, 1914, this patient was referred to us by Dr. W. C. Dugan with the clinical diagnosis of malignancy of the left temple area with metastasis into the cervical glands. His history was, that two months previously he had stuck a beard of wheat into a little pimple which had failed to heal. For three weeks he had been having a great deal of pain referred to the ear, mastoid and cervical glands.

On examination a small malignant ulcer, 1½ cm. in diameter, was found anterior to the ear on the left side. The glands in the neck, five or six in number, were about the size of olives.

He was given three doses of *x*-ray, using an air cooled gas tube that would back up about 8 inches and was run until the resistance was reduced to a 6 inch back up. The other factors were 8 inch skin distance, 5 ma. current, nine minutes' time, 3 mm. of aluminum. This was repeated in two weeks.

After the third dose the patient had a great deal of skin reaction and refused to return, though he reported to his doctor.

The roentgen-ray irritation and healing were over in about four weeks; at present the only evidence is a small white scar, 1 cm. in diameter.

Eight years have elapsed since the malignancy was first noticed, and seven and two-thirds years have elapsed since *x*-ray treatment was given.

[2] Fourteen months have now elapsed since the patient was treated and he remains perfectly well. No evidence of recurrence is present, and the sight is perfect.

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D.C., Sept. 27–30, 1921.

cornea is more resistant to the rays of radium than are the surrounding structures. How many cases have you seen of marked corneal irritation?

In New and Benedict's report,[1] they say, "It is desirable that the cornea shall be protected in treating lesions of the lid in order to prevent a severe reaction, but we have not seen any serious effects on the cornea from the use of radium. For this we have used a screen of lead 2 mm. thick." Their technique is by cocainizing the eye, having the radium placed in a lead applicator for protection to the nurse, who holds the radium in place fifteen to twenty minutes, in direct contact with the lesion; an area of the radium is exposed of the size of the lesion to be treated.

"The American Encyclopedia of Ophthalmology" gives the following brief description: "Although not as rare as true carcinoma, corneal epithelioma is a most unusual neoplasm. Primary epithelioma of the cornea is probably unknown. It occurs as an extension from the limbus where the conjunctival epithelium changes into corneal. The dense fibrous tissue of the cornea does not readily become infiltrated and therefore resists the invasion to a marked degree." Reports of seven cases are to be found in ophthalmic literature, made by the following observers: Snellen, Stellwag, Colsmann, Galezowski, Bossalino, Lagrange, and Treacher Collins. Of this neoplasm Parsons says: "The cases, therefore, of true corneal epitheliomata are extremely rare, and are all open to more or less doubt. It seems probable, however, that the corneal epithelium is capable of malignant proliferation, and that it has

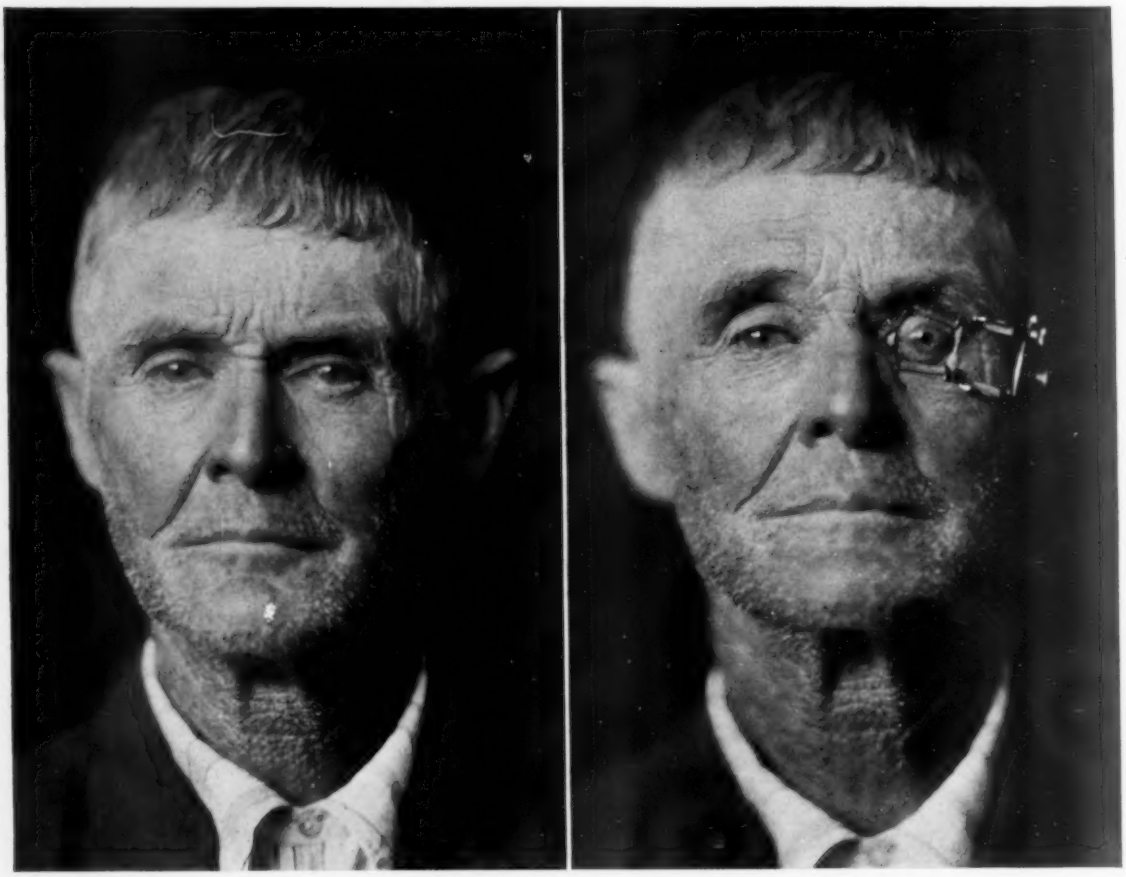

FIG. 1. FIG. 2.

Pictures made four months after application, showing absolutely no evidence of the epithelioma of the cornea. Speculum in place shows method of holding the lids apart during treatment.

but slight tendency to extend deeply (Lagrange). It is rare for epibulbar growths to invade the interior of the eye; epithelioma of the cornea apparently never does. The substantia propria offers some resistance to the invasion, setting up a barrier of embryonic connective tissue around the epithelial cells. The fact that the canal of Schlemm and the anterior perforating vessels lie under the conjunctiva accounts for the fact that the growth never becomes intra-bulbar; added to the fact of the intra-ocular pressure which prevents the growth from bursting through elsewhere. Like all tumors, they grow in the direction of least resistance, which in this case is forwards and peripherally."

"It is extremely noteworthy that no epithelioma of the uninjured cornea has ever been observed." (J. D. L.)

"Bossalino[2] studied an epithelioma which involved more than two-thirds of the corneal surface, in a man of seventy-six years. From microscopic study of the enucleated eye, and from consideration of the views of other authors on the same subject, the following conclusions are reached: To epitheliomatous invasion corneal tissue offers greater resistance than do other tissues. The power of resistance resides especially in Bowman's membrane. The prerequisite for deep extension of such tumors is a transformation of Bowman's membrane into a fibrillary structure."

In the literature at our command we find seven cases spoken of in "The American Encyclopedia of Ophthalmology"[3] which should cover the literature up to 1914.

In more recent literature we find the reports of 6 cases which have been treated by radium or mesothorium with excellent results in all; the dates and authors are as follows:

1. Agricola[4]		1913—1 case
2. Koellner[5]		1917—1 case
3. H. H. Janeway[6]	Nov.,	1919—2 cases
4. G. B. New and W. L. Benedict	March,	1920—1 case
5. T. Collins		1915—1 case

Janeway's first case was given 42 mc. of emanation unfiltered which was applied by a brass cone at a distance of 1 cm. from the lesion for 20 minutes. Nine months later a report from the ophthalmologist stated that the lesion had undergone continuous retrogression and that there was no evidence of disease.

His second patient had shown evidence of a tumor 12 years before, though there had been no increase in size until one and a half years before treatment. Two months before the application of radium it had been excised and a microscopic diagnosis of epithelioma was made. Four roentgen-ray treatments were given after operation, but the tumor promptly recurred, the recurrence being in two isolated areas about the size of a grape-seed and on the scleral conjunctiva external to the corneal margin. Five treatments were given between Sept. 19th and Dec. 15th. The dosage was as follows: 30 mc. filtered by .5 mm. of silver applied at a distance of 1 mm. in an applicator made of dental modeling compound, for one hour. One month later 100 mc. were applied in the same manner for fifteen minutes. On the other dates 20 mc., 46 mc. and 38 mc. respectively were applied at a distance of 1 to 1½ cm. in cones for twenty minutes. The patient was seen again one year later with no evidence of disease and no evidence up to the time of his report in Nov. 1919, which was twenty-six months from the time of the first application. Janeway says, "Such treatments as these are therefore efficacious in destroying epithelioma and do the retina, cornea or the rest of the eye no harm."

He now recommends an applicator made with a hole approximately .5 cm. by 1 cm. in diameter, cut into lead of 2 mm. thickness, one or two radium tubes being placed over the center and fastened to it by paraffin, the eye being fixed on a spot in the wall so that the orbital conjunctiva at the site of the tumor occupies the highest position in the middle of the speculum over which the applicator may be placed.

His recommendations are: silver filtration and two applications, at relatively near dates, of 30 mgm. hours each.

The total number of cases found in literature up to the present time are 13, 6 of which have been treated with mesothorium or radium, the first one being in 1913. From a review of these cases and the one we have observed it is our belief that the application of radium to tumors of the

cornea or the bulbar conjunctiva far excels operative procedure. Several cases were studied in which the patient had had from three to six operations, many of which reported recurrence within two or three months. Should we have a recurrence in the case we have treated, we shall be glad to report it first to this society. There will probably be some criticism as to the dosage we applied, since we used 42 mg. hours to each half of the eye and appreciated that the central portion received enough cross-firing or "splashing over," which accounts for more radiation to this portion of the eye. However, there have been no ill effects, and we would not hestitate to use the same dosage or more on a similar case, as there was no reaction that caused any inconvenience or distress to the patient.

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A SIMPLE PASS BOX

BY CHARLES B. REED, M.D.

NEW YORK CITY

BELIEVING that a simple and safe device for the passing of exposed *x*-ray negatives into the dark room or unloading room will be of interest to roentgenologists, I am submitting the accompanying design.

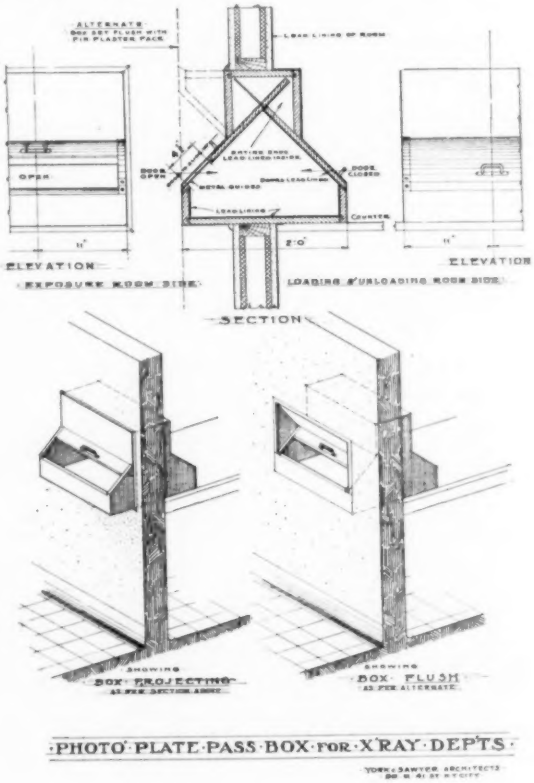
The box was designed for the Fifth Avenue Hospital, New York City, York & Sawyer, Architects, 50 East 41st Street.

It is 72 in. square, inside measurement, which allows the largest size cassette to be handled with ease. The depth below the opening is 4½ in. allowing for a good number of exposed negatives but this can be increased if desired without any change in design.

The sliding door with lead lining offers perfect protection in the dark room from light and *x*-rays. And the construction makes it impossible to open but one door at a time, thus eliminating any chance of accidental exposure in the dark room.

The doors are mounted on metal guides which run easily and close by their own weight, avoiding the need of complicated stops and counterweights.

The box may be set flush on either side, or projecting, as desired. The height should be determined by the dark room counter and the wishes of the operator. The box can be built by any carpenter, and is very simple to operate.



THE UNDERLYING PRINCIPLES IN THE RADIOTHERAPY OF MALIGNANT TUMORS AT THE SURGICAL CLINIC OF PROFESSOR SCHMIEDEN OF THE UNIVERSITY OF FRANKFORT*

BY HANS HOLFELDER, M.D.

University of Frankfort

FRANKFORT-ON-THE-MAIN, GERMANY

BEFORE entering upon the scientific part of my paper, I desire to express my deep appreciation for the invitation to present it before this distinguished society. The reestablishment of scientific communication between the various countries of the world is one of the most important tasks of reconstruction. It was with this feeling that my respected chief, Professor Schmieden, made possible my trip to America. The courtesy which this society has extended to me and to my colleague is greatly appreciated.

During the last few years, the roentgen-ray treatment of malignant growths has made important strides in our country. The extensive use of radiation in the treatment of malignant tumors originated in Germany with the gynecologists, but in the last few years the surgeons have found it necessary to adopt this method of treatment, and find it an invaluable and important aid. So great has the interest of surgeons in *x*-ray therapy become, that at the surgical congress held in April of this year at Berlin, an entire day was given over to the subject of *x*-ray treatment of surgical diseases. The extensive use of modern *x*-ray therapy is now made in all the principal surgical clinics of the hospitals of Europe, in most instances following the lines laid down by the Universities of Frankfort, Freiburg and Erlangen.

In developing my subject I desire to stress five essential points:

1. A far-reaching improvement in apparatus and tubes now permits the production of roentgen rays in sufficient quantity and of a sufficient power of penetration to solve many surgical problems.

2. The improvement permits also of a relatively constant output of rays. The successful application in practice of these newer developments in tubes and apparatus has been made possible by the development of a technique of measuring employing the electroscope and the iontoquantimeter.

3. With the means at hand we have learned that uniform results and permanent success can only be accomplished when every single cell in the whole area of growth receives sufficient and equal dosage. To accomplish this, the aim of technique is to secure an evenly distributed dose of sufficient quantity throughout the entire bulk of the growth. The dose must be neither too small nor too large, but lie within fixed limits, and when of this character is called the "carcinoma dose."

4. The development of powerful roentgen-ray apparatus has taught us the danger of radiating extensive portions of the body and certain vital organs where the full carcinoma dose is employed. We must, therefore, attempt to localize our dosage as nearly as possible to the seat of the disease and its immediate surroundings. The application of large fields has called definite attention to secondary and detrimental results of prolonged radiation.

5. The determination of the lapse of time in which the *x*-ray reaction occurs in the radiated tissues is of the greatest importance. To accomplish this, it is desirable that the whole dose should be applied at one time, and that intervals of necessary length should elapse between radiations in order to permit the biological reaction to run its full course.

6. It is necessary that in the development of this science there should be intimate and thorough cooperation between the physicist and the *x*-ray therapeutist

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

on the one hand and the *x*-ray therapeutist and the surgeon on the other. Only in this way is progress in the right direction possible.

As Professor Lédoux-Lebard and Professor Dessauer in their wonderful papers have already laid down the details of *x*-ray apparatus and the instruments employed in the study of high voltages and quality of *x*-rays, I shall pass over this phase of the subject.

It is necessary for the roentgen-ray practitioner to understand the various factors which determine the penetration or activity of a cone of *x*-rays projected into the human body. The amount projected below the surface decreases by absorption, a certain proportion of the rays in relation to their hardness or penetrating qualities being stopped by the tissue. A further loss occurs by the geometrical divergence of the cone of rays, the loss in this case being as the square of the distance from the focus; this may be called the loss by divergence. These two factors of loss are in part corrected by a small gain through what are known as scatter rays. A simple analogy is the relation of light to an opaque body like milk. The human body is opaque for *x*-rays, hence the rays do not pass straight through; a part of them is dispersed in the tissues in all directions. The amount of scattering rays is dependent upon the bulk of the tissue radiated, and this is dependent upon the size of the cone of rays. The larger the field radiated the greater the percentage of scatter rays, and the less the field the smaller the number. It will thus be seen that the percentage of penetrating rays at a given depth, without altering the quality of these rays and with the loss by absorption remaining constant, may be varied by changing the focal distance between the tube and the skin, and by altering the dimensions of the field radiated. Thus the percentage of rays at a given depth is influenced by the quality of the rays, the size of the field upon the skin, and the distance between the focal point of the tube and the skin.

In order to determine the number of rays which penetrate to a given depth, Wintz has introduced to roentgen therapy the idea of the percentage depth dose. This is the proportion of the surface dose compared with the depth dose measured by means of a phantom with the iontoquantimeter at a depth of 4 inches below the surface and expressed in percentage of the surface dose. The formula is as follows:

$$\text{The percentage depth dose} = \frac{\text{depth dose at 4 inches} \times 100}{\text{(divided by) the surface dose}}$$

The percentage depth dose fixes two points in a curve representing the activity of a given cone of *x*-rays. As we have seen, the value of the percentage depth dose can be improved by changing the distance

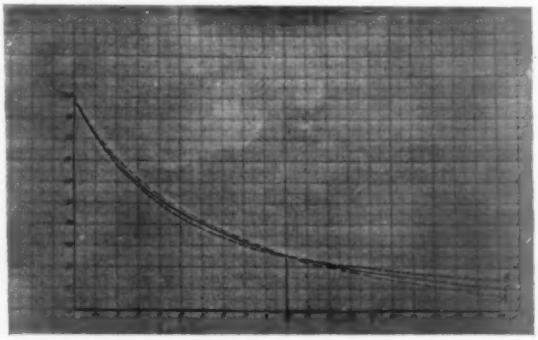


FIG. 1.

between the focal point of the tube and the skin. This may be represented by curve A (Fig. 1). This can also be done by enlarging the field, which would give us curve B. But the difference between curve A and curve B lies well within the field of practical error, so we may therefore content ourselves with a compromise curve lying between these, as curve C. With accurate physical measurements at our disposal, we must determine their value in biological terms before they can be used in practice, and to do this they must be expressed in terms of effect upon the skin. The unit of biological activity in Germany is the so-called skin standard dose (*Haut-Einbeits Dosis* von Seitz und Wintz), and is relatively the same as the erythema dose of this country. In practice it is taken to mean a certain degree of reddening, practically what is called a burn of the first degree, upon the abdominal skin of a patient of middle age. This unit has to be determined by experimental radiation; and having determined the amount of

radiation under given conditions necessary to this end, we then adjust our measuring instruments, usually the iontoquantimeter, thereto.

While measured physically, therapeutic doses are expressed in terms of the erythema dose. Thus it has been determined that the so-called carcinoma dose lies between 90 and 125 per cent of the standard skin or erythema dose.

As it is destructive to apply more than the full standard skin dose upon any one area of skin, and as the cone of *x*-ray decreases in percentage value with the increasing depth, it is only possible to secure the necessary dosage in the depths of the tissue by attacking them with cones projected through individual areas of skin, the so-called cross-fire method. In this method the treatment of cancer becomes an artillery problem, the difficulties of which are increased in surgical cancer by the extent and frequently eccentric position of the lesion.

In treatment of cancer of the uterus the problem is relatively simple because the uterus is centrally placed and can be radiated from four or six sides with the assurance that the limited growth in the uterus will receive sufficient and homogeneous dosage. In surgical cancer the problem is usually much more difficult. The irregular extension of the disease and the eccentric position require, in every case, a special and accurate study to determine the proper solution of the problem. If the growth is extensive, the center may have received the proper dosage, whereas the deeper portion may have received too little and the superficial portion too much. It is essential that the growth should receive uniform and sufficient dosage; and the problem is often complex.

To make possible a graphic study of each problem we have constructed in the Frankfort clinic a device which we have named a field selector. This consists of a box illuminated with electric bulbs from beneath. Over it is placed a translucent plate of glass upon which are printed certain figures which are used as signals. They are printed in one color with the different symbols in percentages of strength of color. A drawing upon a glass plate representing a cross section of the body and showing the location of the vital organs and the location of the growth is now placed over the illuminated plate on which the symbols are printed. We have prepared a series of celluloid dummies representing beams of *x*-ray produced at different voltages and through different values of filters at different distances from the body and of different dimensions of field, on which are shown by decreasing intensity of color starting with one hundred at the surface, the percentage depth dose at varying depths. These are stained with the same color as the symbols printed upon the plate, and when two or more of these dummies are laid upon the diagram in such a way as to cover the lesion, one observes whether the different symbols are visible or whether they have become invisible, when viewed through the superimposed celluloid films. The triangles disappear when 30 to 40 per cent of the standard skin dose is reached in the color values of the dummies. The quadrangles disappear at 60 to 70 per cent of the standard skin dose, and the points at 105 to 115 per cent. The danger signals which are represented by the double dots should at all times be visible. When they are no longer visible, then the dose has exceeded 135 per cent of the standard skin dose and represents an amount of radiation which will cause a burn.

By means of this apparatus one may work out the various combinations of beams of different values, with the possibility of detecting whether we have secured a sufficient dose in the area desired and whether there is, at any point, danger of causing a burn.

I desire to illustrate this method by a picture showing two fields so placed that they overlap each other so that in the center the double points are no longer visible. Obviously here we should have a burn (Fig. 2).

These two fields placed in opposition to each other avoid the possibility of a burn, but one sees that the disappearance of the symbols is of an irregular character and a homogeneous dose cannot be obtained by this combination (Fig. 3).

The next slide illustrates a method by

which three fields are tested. Here also a homogeneous dose is not accomplished and at the margin of the beams where they overlap one sees that there is again danger of burns (Fig. 4). If we remove the beam at the side, we avoid the burn, but the dose at depth is insufficient (Fig. 5). This can be overcome by readjusting the field as shown in the following slide, where, at last, we have a graphic representation of the solution of the problem in this instance, the dose being homogeneous in space and covering uniformly the entire area of the growth.

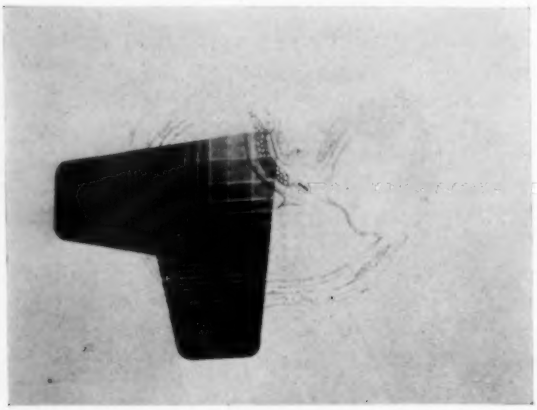


FIG. 2.

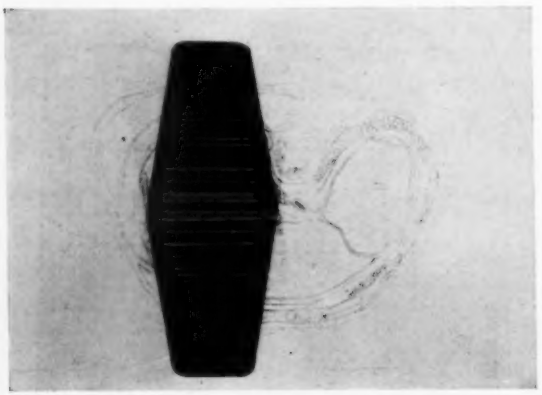


FIG. 3.

This result has been accomplished by using a most penetrating beam upon the skin area nearest to the growth, crossing this cone from the rear with other cones of less penetrating values.

Occasionally the growth lies very superficially, as in cancer of the breast, and here we often find it necessary to apply but one field from in front, obtaining a sufficient and homogeneous dose in the growth by employing large fields and a long focal distance.

These are but a few examples of the uses to which the field selector may be applied,

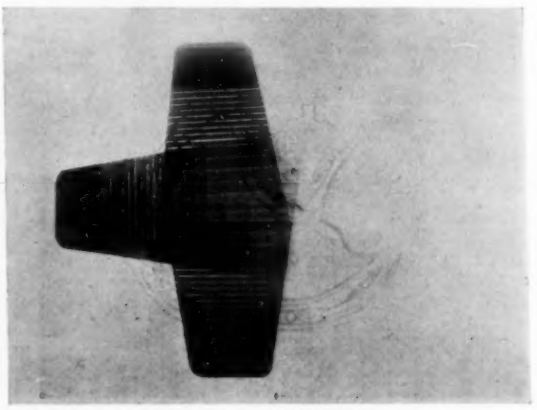


FIG. 4.

but I trust they are sufficient to demonstrate its usefulness. It gives us a graphic method of solving individual problems, keeping constantly before us the various features which must be considered in the solution of the problems. I should be pleased to explain any further details of its use after the lecture to anyone who is interested.

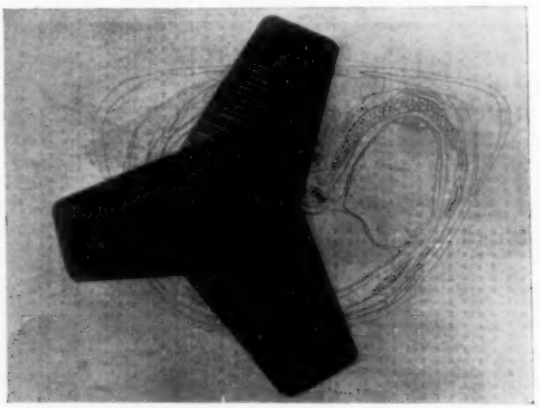


FIG. 5.

As I have stated under Point 3, with the advent of powerful *x*-ray apparatus we have learned that it is harmful to radiate large areas of the body with homogeneous dosage of high percentage value. This is due

largely to the effect upon the circulating blood. Through the assistance of the field selector we seek to limit the high dosage to the tumor and its immediate surroundings and to avoid vital organs as much as possible. In treating cases of cancer of the stomach we found that injury to the adrenals was almost unavoidable, and the result was that transverse radiation of the stomach had to be abandoned. In seeking to solve this problem Peiper and I have radiated the suprarenal bodies of guinea-pigs with narrow *x*-ray cones, and have found that this organ cannot receive a full carcinoma dose without permanent injury. With this in mind we have made a topographical study of the position of the stomach in relation to the adrenals from which it appears that it is impossible to radiate transversely without injury to the latter. As a result of this knowledge we now radiate from in front and below upward and backward in a slanting direction, and the reverse direction in the same plane from behind forward and downward. This only permits effective radiation of that portion of the stomach included in the lesser curvature, but we can in this way avoid the adrenals. By this method, in the last few months, we have successfully radiated a number of cases of cancer of the lesser curvature of the stomach.

Study of the effect upon individual cells in a growth indicates that certain cells are more profoundly influenced by an *x*-ray dose than are others. Furthermore the length of time between the treatment and the full development of the biological reaction is also variable, so that we have a variation in the amount of reaction produced and in the time factor. As it is difficult to estimate the length of time required for the development and cessation of the biological reaction, it is extremely desirable to simplify the problem by applying the full dosage at one sitting. Where divided dosage is employed, there is danger of cumulative effect and difficulty in determining when the full therapeutic dose has been delivered. The biological reaction in the cells following radiation is sometimes as late as two or three months after treatment, and in sarcoma this is frequently the case. It is not unusual to find a sarcoma after treatment that rapidly increases in size and presents all the characteristics of rapid growth, this reaction only subsiding after six or eight weeks, when regression may set in and complete healing follow. In such cases one is likely to err by repeating the treatment or deciding that the case is one for amputation.

From these facts we may deduce the following main rules: Full radiation at one sitting; long intervals of from eight to twelve weeks between treatments. And where the dose is repeated the full dosage should be given, and between the second and third dose a longer period of from twelve to twenty weeks, followed by an interval of six months; in each instance giving the full dosage.

The improvement in technique in surgical roentgenotherapy could not have arrived at its present development without the intimate cooperation of the physicist, the roentgen specialist and the surgeon. The rôle of the physicist has been sufficiently explained. I desire here to emphasize the importance of the surgeon. Surgical diagnosis is necessary in determining the location of the seat of the disease and its extension. To render this possible, Professor Schmieden and I have prepared a great collection of sagittal, frontal, cross and oblique sections of the body in natural size, showing the relations of the vital organs to the surface. It is only with such cross sections available that one can apply deep therapy with topographical accuracy. These constitute the collection of maps of the general staff on which one bases the detailed artillery plan studied on the field selector.

In certain surgical types of cancer one can only determine the exact location of the lesion by surgical means, as, for instance, in cancer of the stomach. In such a case an exploratory laparotomy should be made to ascertain the seat and extension of the growth. In other cases it is necessary that the organ in which the disease has developed should be put to rest, as in cases of cancer of the rectum, where an artificial anus is frequently made for the period of the treatment. In many instances a combination of surgery and roentgen-ray treatment is the most advisable procedure,

and this can only be done where the deep therapy plant is in immediate connection with the surgical hospital. Furthermore, only by close and sympathetic cooperation can the indication be determined as to whether radiation or operation is the most desirable.

Although the effect of radiation in many types of surgical disease is extremely gratifying, n fact, in many instances quite astounding, the results are yet not sufficiently uniform to justify abandoning surgical operation in operable cancer except under special conditions. Time will not permit an analysis of these exceptions.

In a few closing sentences I desire to set forth the present status of our clinical experience and the indications which determine our handling of cases at the surgical clinic in Frankfort.

1. Every operable cancer, with few exceptions, is operated and in addition receives prophylactic radiation afterwards. This radiation is carried out exactly as if the growth were still present.

2. Besides prophylactic after-radiation, radiation before operation is generally practiced, and is considered of great importance.

3. All inoperable cancers and all recurrences are radiated unless too advanced. In a certain proportion of cases, clinical healing will result in a further improvement sufficient to permit operation to follow the treatment, and in many cases the danger of bleeding, ichor and pains will be diminished or disappear, and the chance of metastasis be diminished.

4. Where the primary growth is operable but there are remote metastases in other organs, as, for instance, a primary cancer of the rectum with metastases in the liver, the primary growth is removed by operation and the metastases in the liver are treated by *x*-rays alone.

5. Epitheliomata of the skin are exclusively dealt with by *x*-ray treatment.

6. The great majority of sarcomata are treated by radiation alone. The time has passed when amputations for sarcoma are made any longer in the Frankfort clinic. Apparent increase in size of growth following radiation should not lead to discontinuance of treatment or amputation.

7. Our methods have been mainly based on the technique of Seitz and Wintz. We have attempted to adapt their method, by means of the field selector and topographical sections of the body, to the field of surgery. We have enjoyed the privilege of close cooperation with the Physical Research Laboratory of Professor Dessauer.

8. Improvement in the techinque of *x*-ray treatments must be based upon careful and accurate observations and practical experience carried over a long period of time, involving careful studies and adequate records.

9. The aim is to secure a homogeneous radiation of the whole seat of the disease, the dose to be determined by the biological qualities of the case.

10. Unscientific and improper radiation will gravely complicate any case and make ineffective suitable procedures applied afterward. The prognosis of improperly radiated cases is extremely bad.

11. Once a case has been radiated in a given institute it should pursue the treatment only at this institution and under the same responsibility. Surgical cooperation is of greatest importance.

12. The frequent changes in technique and continual advances in the field of radiotherapy make it impossible to distinguish statistically between the value of operative and radiative treatment. We shall continue at the Frankfort clinic along the lines indicated in this paper until the relative value of both methods is finally decided.

DISCUSSION OF PAPERS ON DEEP ROENTGENOTHERAPY BY PROFESSOR DESSAUER, DOCTORS STERN, STEWART AND HOLFELDER

DR. STERN. How long before operation do they give pre-operative treatment?

DR. SCHMITZ. I wish to fulfil a promise that I made, and that is to discuss this paper. Two points of greatest importance to be taken from Dr. Dessauer's paper are: 1, radiation must be of homogenous quality; by that he means that the healthy and diseased tissue must be struck by the same kind of radiation, otherwise it is impossible to compare the biological results on the surface with those in the depth, because rays in the depth differ from the surface: 2, radiation must not only be homogeneous qualitatively but also quantitatively; by that is meant the entire diseased area. Practically all of the body which is within the radiation cone must be struck by radiation of homogenous intensity. The question arises in our minds, how this is brought about. In the following way: First place, select proper focus skin distance. We should never say 50 or 30 cm. but we should select for each case individual focus skin distance to be used in that particular case. In order to increase the homogenous radiation qualitatively and quantitatively, you must make the depth dose practically as intense as the surface. You certainly must use a filter which will cut out the undesirable radiation; that is, the soft long rays. Selection of the proper filter thickness and the kind of filer is very important. If you are radiating any benign condition, such as a bleeding uterus where you should cause with the *x*-ray a cessation of menstruation, you need only practically 35 per cent of an erythema skin dose. In cancer of the uterus you need 100 per cent. In cessation of menstruation it is only necessary to strike the ovaries and it only takes 35 per cent of an erythema to obtain results. The selection of the number of ports of entry and also the size of the ports of entry are very important.

It is almost incomprehensible that any one can say they can obtain better or the same results with the old gas tube than with the Coolidge tube. The same conditions can never be reproduced with the gas tube as with the Coolidge tube.

DR. LEVIN. Mr. President: Allow me to congratulate you on the wonderful program of the meetings of yesterday and today. The lecture delivered by Prof. Lédoux-Lebard was particularly interesting to me. There cannot be any doubt in anybody's mind that the more perfect the construction of the *x*-ray machines, the larger the quantities of radium employed, and the more perfect the methods of application and measurement, the better will be the therapeutic results. None the less, the biological and pathological conditions within the organism of the patient are so complex that uniform results cannot be expected, all the assertions to the contrary notwithstanding.

The following 2 cases of lymphatic leukemia, in both of which the same quantity of radium was applied for the same number of hours to the spleen, bear out strikingly this statement. In one case the total leucocyte count was reduced from about 180,000 whites to about 32,000, the lymph-glands diminished in size and the general condition of the patient improved. In the other patient the total white count went down from 280,000 to 1,000, and notwithstanding several blood transfusions the patient died in seventy-two hours after the irradiation. This remarkable difference in the action of the same quality and quantity of radiation on two patients suffering apparently from the identical disease, must serve as a warning against the indiscriminate use of the so-called carcinoma dose, sarcoma dose, castration dose, etc. Every cancer cell is an organism in itself which constantly takes in food and secretes products of its own metabolism, which later again may serve as food to the cells of the neighboring tissues. Local and temporary differences in such metabolic inter- and intracellular activities may well account for the differences in the results of an identical amount and quality of radiation. Three patients with carcinoma of the breast, one of which is a strong woman of twenty-eight, the second over eighty years of age and the third a woman fifty years old and suffering from diabetes besides the cancer may well react differently to the same carcinoma dose of *x*-rays.

The work of the physicists contributes greatly to the progress of the science of radiotherapy and the high voltage *x*-ray machines will add to the efficiency of the work, but a great deal of thought and care should be exercised in the use of these powerful engines.

DR. PFAHLER. I appreciate this excellent presentation by those who have studied the clinics in Europe. Dr. Levine has already sounded part of the thought that I intended to sound,—or a warning if you please. We get

the impression from these reports that the first essentials are that we have an instrument that will deliver 200,000 volts; that we have a patient to work on; that we use the technique and be sure to deliver sufficient dosage into this patient. Now all this discussion so far seems to have lost sight of the fact of the patient being a living human being with a will of his own, with a lot of friends—and some with lawyers. Do not forget the last mentioned gentlemen. With this new technique which is unfamiliar to most of the men in this room, if you go ahead and try to do offhand, by your own experience and your own knowledge, what has been done in these carefully controlled clinics in Europe, where a physicist stands by your side and where a surgeon has made a preliminary examination and helped to control the progress of the case, and where a trained roentgenologist or radiologist has given the treatment—if you attempt to repeat offhand without the same amount of knowledge and support, what they have done, there is going to be trouble. Hundreds of law suits will result from this enthusiasm. We must be careful and go into this new technique carefully or we are going to do harm. As a practical point, I want to ask a few questions from these men who have made observations in European clinics.

What is done over there to prevent radiation sickness? the general symptoms of the patient which already bother us even with our "play" radiation? Tell us what they are doing to overcome it, or prevent it. They do not repeat radiation until the blood has returned to normal. Will Dr. Stewart tell us how far the blood has gone abnormal and what we should look for in the abnormality of that blood?

Will they tell us what is being done for the skin of these patients in which Dr. Schmitz has already told us that he intends to bring about a dermatitis? Tell us what to do. In some states *x*-ray dermatitis is prima facie evidence of negligence.

Dr. Pariseau. Just in an offhand way I shall give you a few of the reflections that have come to my mind. I think it is not absolutely necessary to sound any more alarms. The voice of common sense has been heard several times within the last forty-eight hours; heard in very liberal and very forceful language. Whatever the form of it, whether it be elegant or impoverished, I think it is the voice of common sense speaking.

Nevertheless, I have been thinking a good deal about what I should do to perfect my technique. I wondered what I could do to make my present 9 or 10 in. technique a little better. I gave before the Canadian Radiological Society at Niagara Falls in June what I called "Basic notions of physicis and elementary mathematics" which we have too often forgotten. When a man says "I am at present using an 8 in. target skin distance, but if I used 6 in. I would certainly shorten the exposure," he evidently said a truism; on the other hand he was admitting an error in technique, since, as he was getting nearer to the patient he was losing what we need very much—homogeneity. I gave what they were worth, these basic notions. I have been thinking ever since what I could do. One thing is sure; our measurements need to be as well standardized as possible. If I had to put it in tabloid form I should say, "The measure of our progress is the progress of our measures." As a great Frenchman said, the notion of measurements must penetrate all of medicine. We must use a given spark gap and not say "between blunt points." When we get these basic notions of elementary mathematics, etc., it seems to me that there are a good many other things we want to acquire. Among them is skill in handling machinery. We have heard how many have failed to direct the central ray. I have often done in a slipshod way radiation of the ovary and uterus. Now it is true that with a large port of entry the misdirection of our ray will have less effect because we can count on the scattered ray, at any rate, reaching the organ we want to treat, but it is quite evident that the real primary concentrated ray is the one we want to get there.

With a cardboard box, I have at home evolved a method, not new, and which I tried once at the hospital. It is not easy in cancer of the cervix, for instance, to know just where the cervix actually lies. Make a pessary and put it down into the cervix and fluoroscope your patient. You will get somewhere on the abdomen the spot, which you can mark with ink, where your perpendicular ray from the tube strikes. Shift your tube sideways and get another spot. Now you have something which you can materialize.

Regarding the ionization chamber, Villard tried to construct one, but could not have it done in Paris on account of the indifference of his French mechanics, so he had it constructed in Germany. I think that first, if we are to use it, we must choose a small one that can be put into the cavity. An ionization chamber of aluminum would give very grave discrepancies on account of the characteristic radiation which would be emitted inside the chamber. I understand that Dr. Friedenwald modified his aluminum ionization chamber and now uses one composed of an organic substance, lined

on the interior with graphite, which has not characteristic radiation worth mentioning; so it would seem to me that we are jumping into a problem without having, perhaps, sufficient knowledge of the fundamentals.

DR. CASE. I want to ask a question of the gentlemen who have recently been to Europe. We understand from their remarks today that the trend of surgical opinion in Germany is away from surgery and toward radiotherapy in dealing with operable cases of cancer of the breast and pelvis. I am perfectly willing to believe that this is true in the clinics in which these gentlemen visited. I would like to ask, however, whether or not they have made wide inquiry in many clinics regarding the general trend of surgical opinion in Germany as to this question. I really wonder if it is true that surgeons as a rule have adopted this method as much in toto as we might believe from the very encouraging reports.

As regards locating the cervix, if one combines radium with *x*-ray, naturally one applies the radium first, and it is a very simple matter to fluoroscope your radium capsules in position and determine from what angle the *x*-rays are to be applied. If no radium is used, it is a simple matter to insert a small metal pessary, which can be fluoroscoped and then removed.

I have been interested in the question of deep therapy for about six years. In 1915 we had constructed for our laboratories one of the larger Peerless machines, with a large rectifying switch. This we used for treatment work as early as 1915 with copper filters, but at that time we did not attempt to employ more than a 10 in. air gap voltage. The war came on and the question was dropped until the year 1919 when I found that our apparatus would give us a much higher voltage. Through a series of fortunate circumstances I was placed in possession of a Coolidge tube of the new type about seven months ago, and we were able to start treatment with it and to measure with the sphere gap our voltage, which varied between 180,000 and 196,000. We had not the slightest difficulty in the running of the machine.

About a month ago we got our new machine, which gives upwards of 200,000 volts. We have been using 220,000 volts in a number of cases, and can work as high as 280,000.

I have been asked to express my opinion of the new treatment and its results. I feel reluctant to put myself in evidence after only six or seven months' experience with the higher voltage. You are familiar with the results we have been obtaining through months back with the ordinary technique. I have been very definitely impressed with the fact that since we have increased the voltage and have been using copper filters, upwards of 1 mm. thickness, increased the dose, and increased the focus skin distance, we have thus far secured temporary results in cancer cases which are certainly infinitely superior to any we have heretofore seen. We cannot talk about these patients as cured; it is almost beyond belief that we have attained anything like that. But very extensive recurrences have melted away at a hitherto unseen rapid rate; tumors have subsided after a single application; unusually prompt and marked relief from pain has been noted in a number of cases. In benign cases we have secured amenorrhea more quickly than before, just as we have secured quicker diminution of the metabolic rate in hyperthyroidism. In malignant cases we have seen improvement at a far greater rate than we have ever seen before. We are very much encouraged and very hopeful. We have received encouraging surprises. I am glad to say that so far we have not had any bad results. We have had no patients who have been extremely sick; the sickest patient was a Hodgkins case.

We have given areas about 15 to 20 cm. square; the longest treatment was 600 ma. minutes with upwards of 200,000 volts at 50 cm., using 1 mm. and sometimes more of copper, plus leather. We gave 5 ma. for two hours at one sitting. However, the average dose is somewhat less than that. With one exception, no patient was sick longer than a day or two. In fact, they are no sicker than after the old method of treatment.

DR. COOLIDGE. There is just one point I would like to bring out; namely, that there is a difference between, on the one hand, merely using an ionization chamber with some form of electroscope to determine absorption curves and, on the other hand, using it, as in the case of the iontoquantimeter, to measure dosage. I do not think that difference has been clearly brought out. In the latter case it has been customary to take the instrument on faith and to measure dosage with it. It is like taking a milliammeter on faith. This is probably done a great deal, but it is not good practice. The milliammeter, no matter who made it, should be calibrated and this should be done frequently, and it should preferably always be used in series with a second milliammeter. Exactly the same thing applies, and with equal force, to the matter of the iontoquantimeter. If it is to be used in body cavities to measure dosage delivered, it seems to me that the instrument should be calibrated frequently, by the Bureau of Standards or some other capable and reliable institution.

Frequent calibrations can be safely dispensed with, only when such an instrument is used for getting *relative* values, as in measuring the output of one tube in terms of another, or in making absorption curves, or in measuring percentage depth intensity.

In connection with the use of the iontoquantimeter for measuring dosage, it should be remembered that expression of the dose delivered, in electrostatic units, says nothing whatever about the quality of the radiation.

If Dr. Friedrich is right in concluding from his experiments that the quality is unimportant, and that regardless of it, biological effect is proportional to ionization as measured by a suitably designed ionization chamber, it might be sufficient to merely state the dose of radiation, as expressed in electrostatic units, delivered at various points. Until this important conclusion of Dr. Friedrich has been adequately verified by others, however, it would seem much safer, even for those who want to measure dosage with an iontoquantimeter, to measure and record also the voltage, as measured by sphere gap, the milliamperage, and the time, together with the factors of distance, filter, port of entry, etc.

Dr. Shearer. There is very little I can add to what has been said by Dr. Coolidge and others. I do want to emphasize one or two points. Observation of work with ionization chambers by fairly good physicists during the last ten years makes me feel very doubtful of the value of such instruments for actual therapeutic dosage where neither working conditions nor the training of observers are favorable to reliable work. Inaccuracies due to stray or parasitic radiation, leakage, characteristic rays due to *x*-rays striking the walls, gradual failure of insulators, etc., are so probable and so serious that I am quite frank to say I would not permit a member of my family to be subjected to deep therapy as here described on the basis of such measurements alone. I would much rather depend on even crude voltage measurements and those of current, time and distance.

The quantimeter gives you a fraction of the amount of radiation that goes through the tissue but not always the same fraction as you raise your operating voltage. You may compare that received with the amount which falls on the skin, but unless you have other information you still do not know the real distribution of that radiation through the various layers of tissue. For that you must depend on one of two things; you must either take measurements worked out on a rather elaborate experimental scale or you must go back to the method mentioned.

Dr. Sittenfield. About a year ago I had the pleasure of presenting to you the newer technique of radiotherapy as I observed it abroad. I was so impressed at the time with the advancement that I brought over an apparatus, and followed up their technique. However I was disappointed that I did not get quite the results they obtained, and in order to check up my own results with theirs, I went abroad this year again. I found that the shortcomings in my results were purely my own; that the technique as used over there is very technical and highly specialized, and can not be repeated by any one with a big apparatus, an increased spark gap, and a high voltage tube.

Personally I have given from two to four hours of radiation at one sitting without any untoward results. My guide for repeating the dose is necessarily the blood reparation. The blood, as you know, generally suffers after severe radiation, the lymphocytes suffering most. Besides, there is considerable reduction of red blood cells, and with it, also, loss in the number of leukocytes.

Abroad, the treatment of intensive radiation consists not only of raying, but of keeping in touch with the patient, if necessary, for several weeks after radiation. This is a most important point to bear in mind. They lay as much stress on the treatment after the raying, as on the radiation itself. The whole crux of the situation is not the apparatus, the tube, the focal distance, nor the portals of entry, but the dosage itself. How you are going to arrive at an accurate dosage depends upon your own calculation and upon the situation of the tumor.

Personally I agree with Drs. Stern and Stewart. I am going to continue along that line. I have worked with Dr. Dessauer's measurements and those of Dr. Friedrich. Dr. Friedrich has devised a simplified apparatus for measuring the radiation that a nurse can handle. I am not going into the question as to whether it is physically accurate or not; for all practical purposes it works well. I have seen hundreds of cases treated with this new technique, and have not seen a burn. My cases do not fare any worse than before the newer therapy.

Dr. Dessauer (closing discussion). The physicist cannot do the work of the biologist. He can only take care of the physical side of the problem. The biological side must, of course, also be taken care of.

It is not surprising that there have been many fatalities. It is rather surprising that

there have not been more. It is often found that the rule has been to measure after instead of before giving treatment. It is not possible to handle all kinds of deep therapy with the voltage corresponding to a 10 in. spark gap; the good results reported by Dr. Pfahler might have been still if he had had higher voltage to work with; the physical means must be adequate for the work to be done. Eventually, when we reach a point where we are sure of our voltage and milliampérage and other physical conditions, and then have, as we now have, our equal intensity curves, it will probably not be necessary to use the iontoquantimeter or any other means of controlling the kind or amount of rays. At the present time we have not reached that point, and it still seems desirable, at least occasionally, to control the character of radiation by direct measurement, as with the ionization chamber.

It is to be hoped that it will not be necessary for you in this country to cope with all the difficulties that have had to be overcome in getting to the point where we are now in our deep therapy in Germany, and it is with this thought in mind that I have come here to tell you about our work.

In closing let me point out that the surgeon spends a long time in the study of his profession. The same thorough preparation is needed for the practice of radiation if the best possible results are to be obtained.[1]

Dr. Stern (closing discussion). This meeting takes me back to the time when Dr. Coolidge first presented his tube. At that time warnings came from all directions about the terrible calamities that would surely follow the advent of this powerful tube. As far as I know nothing dreadful really happened. In fact I feel sure that it put roentgenotherapy on a much safer basis. We realized the power we were dealing with, and took precautions accordingly. It will be the same with this apparatus. I predict that you will have no more trouble in working with 200,000 than with 120,000 volts. Simply realize that you are working with greater power, learn the technique and be careful.

I am getting one of these machines, and expect to do a little experimenting with it, before deciding as to what technique to adopt. I am sure that we can play absolutely safe, and still do a great deal more for our patients than we are doing at present. We do not have to begin with a seven-hour treatment, but may begin with one of the milder forms of technique that I described to you, and gradually work up towards the safety limit.

[1] Translation by Dr. Coolidge.

As for radiation sickness, I found that some clinics were getting a great deal of it, especially those that were giving the entire dose in one or two days. The stand they took was that this was a radical treatment, intended to take the place of a radical operation in an effort to cure malignant disease, and that the constitutional disturbances following the treatment were no greater than those following an operation. In other clinics they assured me that by taking proper precautions they got very little radiation sickness. Dr. Kohler claims that by giving these patients two uzara tablets one-half hour before the treatment, and repeating the dose after the treatment, he practically avoids radiation sickness altogether. These tablets contain no opiates and are considered perfectly harmless. As regards skin reactions, they all aim to get some erythema; some more, others less: but this should always disappear in a week or two.

Dr. Case asked whether all surgeons have stopped operating on breast and uterine cancers. They have not. The majority are still operating. They have only stopped in gynecological clinics, where the surgeon in charge has also charge of the roentgenotherapy department. And it makes no difference to him whether he operates or radiates. He says he prefers radiation, because he gets a larger percentage of cures. I predict that five years from now we shall be assembled at another meeting, discussing the dangers connected with the operation of a 400,000 volt machine.

Dr. Stewart (closing discussion). I have not had any personal experience with the 200 kv. machines. My paper was simply my observations made in Germany this summer, on deep roentgen-ray therapy. The iontoquantimeter is considered a very reliable instrument and apparently is simplicity itself. The nurse in charge of the treatments determines by this apparatus when she has given the prescribed dose. No doubt adjustments and care of the apparatus are necessary. It certainly is a great advantage to have a trained physicist to watch out for the pit-falls in the use of the ionizing chamber for measurement of dose.

Dr Stern has answered Dr. Case with reference to surgeons in Germany. The situation of the gynecologists in relation to this question is much the same as the attitude of the nose and throat men toward the treatment of enlarged tonsils by the *x*-ray. There is a certain percentage of them who are not in favor of it.

The question was asked as to the method of treatment of the 10 cases I saw in Berlin. In 1913 and 1914 they were not using such heavy

voltage. All the cases showed permanent skin changes, indicating cross-fire treatment, with full erythema doses. Many of them used radium in conjunction with *x*-ray.

Dr. Pfahler referred to the blood picture. If I remember rightly the white cells drop from about 7,000 down to about 2,000, the hemoglobin dropping correspondingly. They would not give another treatment until the blood picture had returned to normal.

DR. HOLFELDER (closing discussion). If the patient is to be treated before operation, we treat him three or four weeks before. Patients get more sick after heavy treatment than after a light one.

1. My Studies on the Physical Foundations of Deep Therapy Treatment. By Prof. Dr. Friedrich Dessauer, Director of the Institution for the Study of the Physical Laws of Medicine, University of Frankfort, Frankfort-on-the-Main, Germany. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. AM. J. ROENTGENOL., Oct., 1921, viii, 578.

2. Intensive *X*-Ray Therapy as seen Practiced in the Clinics in Europe. By Samuel Stern, M.D., Radiotherapist to Mount Sinai Hospital, New York City. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. AM. J. ROENTGENOL., Dec., 1921, viii, 739.

3. The Present Status of Deep Roentgenotherapy in Europe. By W. H. Stewart, M.D., New York City. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. AM. J. ROENTGENOL., May, 1922, ix, 315.

4. The Underlying Principles in the Roentgenotherapy of Malignant Tumors at the Surgical Clinic of Prof. Schmieden of the University of Frankfort. By Hans Holfelder, M.D., University of Frankfort, Frankfort-on-the-Main, Germany. Read at the Twenty-Second Annual Meeting of The American Roentgen Ray Society, Washington, D. C., Sept. 27–30, 1921. AM. J. ROENTGENOL., June, 1922, ix, 344.

PYELITIS OF PREGNANCY*

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RICHMOND, VIRGINIA

PYELITIS of pregnancy was first described by Smellie in 1752. Reblaub in 1892 discussed the subject more in detail, reporting several cases with their treatment. The majority of writers (Danforth, Braasch, Geisinger, Walker, Kelley, Baughman, and others) believe that the condition is due to pressure of the pregnant uterus on the ureter, especially the right, at or near the brim of the pelvis. Weibel in a study of 100 normal pregnant women, found that 40 per cent of primip. and 34 per cent of multip. showed definite interference in the ureteral flow.

Aynesworth, however, due to the fact that the majority of his cases began in the early months of pregnancy, does not believe that the uterus is an important factor in the etiology of pyelitis. In the first few months of pregnancy, however, before the uterus has lifted itself out of the pelvis, the pressure on the ureters is greatest, except when the presenting part is in the pelvis.

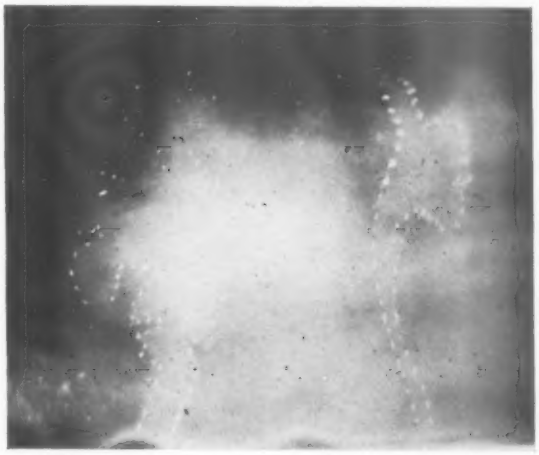
It has been argued that since the specific gravity of the uterus is the same as that of any other intra-abdominal organ, there can be no pressure on the ureters. This argument, however, does not take into consideration the definite traction exerted by the lower uterine segment. The general concensus of opinion is that it is largely a unilateral disease, the right side being nearly always affected.

Harris in 32 cases found the right kidney involved in all, and both kidneys in 6 cases. Pollack in 35 autopsies found 18 bilateral cases, and 17 involving the right side alone. Albeck (quoted by Vineberg) in 125 cases found the right kidney affected 91 times; the left kidney 22 times; and both kidneys 10 times. Opitz in 69 cases found the right side only, affected in 50. Chace in 42 cases collected, found the right side affected 37 times, the left 4 times.

The frequency of right-sided hydronephrosis is due to the uterus passing before the mesentery and being deflected to the right. Francke and Mirabeau believe there is a direct communication between the lymphatics of the ascending colon and

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

the right kidney capsule, making an additional factor in the frequency of the right-sided infection.



Case I. Fig. 1, eight months pregnant.

The assumption of practically all writers at present is that the infection is a hematogenous one, but some still adhere to the ascending route theory. Eisendrath believes there is a direct communication between the bladder and kidney, by way of the perivesical lymphatics. Cabot and Crabtree, in a very thorough piece of work were, however, unable to agree with this assumption. They do not consider ascending infection likely, without dilatation of the ureterovesical sphincter, or obstruction at or below this sphincter. They believe infection from the bladder enters the perivesical lymphatics, reaches the bloodstream, and then the kidneys. Draper and Braasch could obtain ascending renal infection only by maintaining a high pressure over a long period of time.

The colon bacillus is the direct cause of pyelitis of pregnancy in from 75 to 90 per cent of the cases. Bugbee found 75 per cent bilateral infection. The staphylococcus, streptococcus, and other organisms play a minor rôle. The symptoms are usually pain and tenderness in the affected kidney, in the corresponding costovertebral angle, and along the lower ureter; fever, possibly chills, leucocytosis, urinary symptoms, pyuria, and the demonstration of the infecting organism.

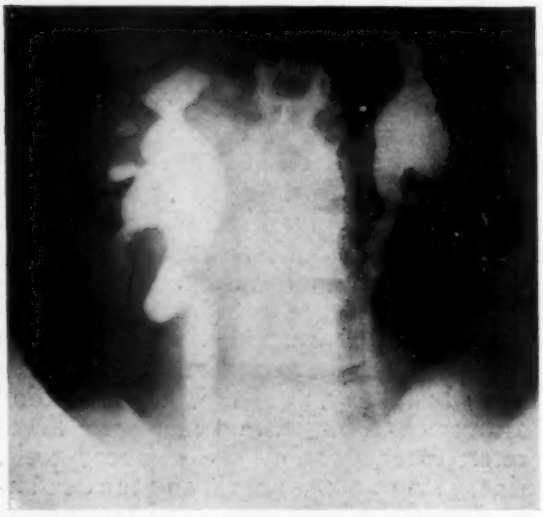
We have studied 15 cases of pyelitis of pregnancy, but will report very briefly 7 cases only. These show the characteristic changes occurring in the renal pelvis and ureters.

Case I. Fig. 2, eleven days after delivery.

Case I. Fig. 3, five weeks after delivery.

Case I. Mrs. J. T. D. Age 24 years. Past history negative. One healthy child, normal delivery. Was eight months preg-

nant at time of examination. Chief complaint, nausea, vomiting, tenderness over both kidneys, especially the right, and



Case I. Fig. 4, five months after delivery.

fever. There was slight leucocytosis and pus in the urine. Cystoscopic examination showed right side pyonephrosis. After five irrigations which extended over a period of fifteen days, a pyelogram was made. This showed marked dilatation of the right pelvis, calyces, and ureter, both ureters being rather tortuous, but no distinct strictures. On Nov. 19th, or at about eight and a half months pregnancy, a normal child was delivered. Pelvic lavage was continued for eleven weeks, the patient continually improving during this time. Seven pyelograms were made at about two-week intervals, these showing a gradual return of the pelvis and ureters toward normal. The right pelvis and ureter, however, have been too much damaged ever to show a normal pyelogram, though the urine and function show nothing abnormal. In this particular type of case, future pyelograms may present bewildering evidence, unless the roentgenologist goes carefully into the past history.

Case II. Mrs. J. M. C. Age 25 years. Past history negative. Two healthy children, one miscarriage. Wassermann negative. The last menstruation was from June 26 to July 1, 1919. With normal urine until Feb. 23, 1920. At this time she was suffering with nausea, vomiting, pain in the back and over the right kidney. Catheterized urine showed pus, and colon bacilli from both sides. Pelvic lavage relieved the majority of the symptoms, though the pyelogram showed marked dilatation of right pelvis, calyces, and ureter, with moderate dilatation on the left side. Ten days before the calculated

Case II. Fig. 5, eight months pregnant.

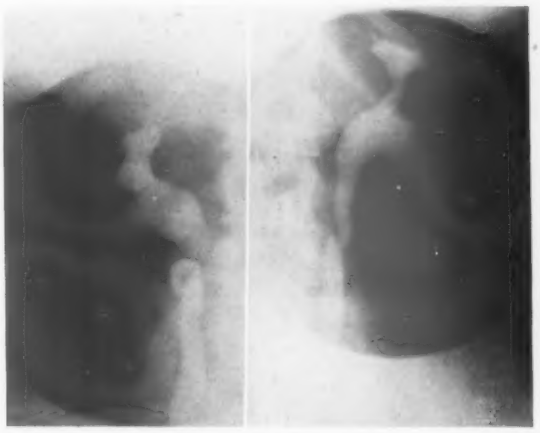
Case II. Fig. 6, after delivery.

date of delivery, she again had some nausea which was relieved by pelvic lavage. The computed time was so near that labor was induced and a healthy child delivered. Two weeks after delivery, pelvic lavage was again followed by progressive improvement in all symptoms. On July 8, a catheterized specimen showed no pus nor casts. The size of the kidney pelves gradually became smaller; but the right side in this case, in spite of a normal function and urine, will probably never again show a normal pyelogram.

Case III. Fig. 7, six and a half months pregnant.

Case III. Mrs. R. C. H. Age 26 years. Past history negative. No children. Last menstruation June 1 to 5, 1919. Probable date of delivery around March 7, 1920. On Nov. 14, she had pain in the back and right side, temperature 104, leucocytes 16,000, polys 90 per cent. The urine showed pus and colon bacilli from both sides. Immediate improvement followed pelvic lavage. After the sixth treatment, a pyelogram showed marked dilatation of the right pelvis, calyces, and ureter; moderate dilatation on the left side. On Jan. 19, 1920, immediately after an irrigation with 2 per cent nitrate of silver, this patient went home contrary to advice. After a restless night, labor pains began, and the next day an eight months baby was delivered. This died the same day. This was the only case where a live and healthy baby was not delivered.

Case IV. Mrs. R. T. A. Age 23 years. No children. Pregnant four months. Chief complaint, pain in right kidney area, and fever. The urine from both sides contained the colon bacilli and pus, usually more pus coming from the right side. A pyelogram revealed a moderate hydronephrosis on the right side, slight hydronephrosis on the left. She has been markedly benefited by lavage, and has recently had a normal delivery.



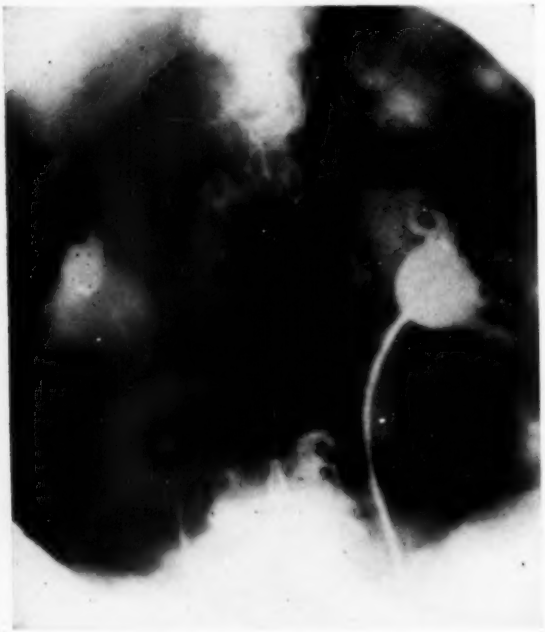
Case IV. Fig. 8, five months pregnant.

Case V. Mrs. J. M. Age 29 years. Three children. Past history negative, except gave history of pyelitis at time of pregnancy five years ago. Cystoscopic examination showed a right side hydronephrosis; no pus or bacilli. There was no obstruction, a No. 9 catheter passing without difficulty. The pyelogram showed a dilated pelvis and tortuous ureter. The left side was not examined.

Case VI. Mrs. W. Age 31 years. Five children, one miscarriage. Gave history of pyelitis at time of her last pregnancy five months ago. Has had some pain in the right side since that time. The urine shows pus, and the colon bacilli from both sides. No obstruction in ureter. A pyelogram showed a dilatation of both pelves and ureters. The symptoms were relieved and urine cleared of both pus and bacteria by lavage. An earlier diagnosis and treatment in this case would in all probability have prevented several months of invalidism and, to some degree, the amount of pathology later found.

Case VII. Mrs. S. B. B. Age 62 years. Five children, youngest 30 years of age. Past history negative. When cystoscoped, No. 9 catheters could easily be passed up to either kidney. With an absolutely negative history, and no spasm, stricture, or other obstruction in ureters, we believe the bilateral hydronephrosis probably followed ureteral obstruction during pregnancy.

The symptoms, laboratory findings,



Case VII. Fig. 9. See case history.

cystoscopic evidence, and pyelographic data in these cases are all very similar. In every instance except one, the colon bacillus was found on both sides. In one case the staphylococcus was also present. In every case the lesion was bilateral, but more marked on the right side. The lymphatic connection of the right kidney capsule with the ascending colon may more promptly add infection to obstruction on the right side; but since the infection was bilateral in practically every instance, the greater obstruction, together with certain anatomical peculiarities on the right side may be entirely responsible for the greater pathology on this side, with no direct relation to the route of infection.

It is generally assumed that coccal infections, since they largely affect the cortex of the kidney and not the tubules, do not give a marked lowering of the kidney function; but that colon bacillus infections, on the other hand, where there is a primary lesion in the tubules followed by pelvic infection, do give a marked lowering of the renal function. We have not found this to be the case in pyelitis of pregnancy, even though the infection is nearly always due to the colon bacillus; kidney function, though variable, has rarely been very low. In a few instances the function has been above normal; in a good many others, practically normal; in none of the cases was it as low as would be expected from the amount of pathology present.

Pelvic lavage using silver nitrate, mercurocrom, or formaldehyde was done by Dr. Geisinger. This unquestionably was of marked benefit. It was followed by very little reaction, but by early relief of symptoms, a decrease in the amount of pus and bacteria in the urine, and improvement in the patient's general condition. Nephrotomy or nephrectomy, as advocated by some, E. P. Davis, etc., is probably very rarely, if ever, justified; while induction of labor is rarely indicated.

The technique for obtaining a good pyelogram in a pregnant woman is of some importance. In our more recent cases, the following technique has given almost perfect satisfaction. The usual kidney cone; film with double screen; 40 ma; 5 inch gap; ½ to 1½ sec. exposure. Only one side is examined at a time, the pelvis being slowly filled under fluoroscopic control. When the examination is made in this way, the patient is subjected to practically no discomfort or reaction, while a good pyelogram is obtained.

This subject being still under investigation, any conclusions can only be tentative, but we believe the following summary is probably justified:

1. Pyelitis occurring during pregnancy is probably uniformly secondary to obstruction due to pressure on the ureter by the enlarging uterus.

2. Usually, due to the rotation of the uterus to the right, the greatest pressure is exerted on the right side; but, contrary to the usual assumption, the left side is

in nearly every instance also affected, but to a lesser degree.

3. Be the source and route of the infection what it may, obstruction unquestionably exists, since in every instance immediate improvement followed evacuation of the uterus.

4. Measurements of the pelvic capacity usually give most of the desired information, but the evidence furnished by the pyelogram is conclusive, serial pyelograms giving a permanent record and graphic data which is of value in treatment and prognosis.

5. The true pathology of the condition is graphically demonstrated by the pyelogram and consists mainly of dilatation of the renal pelvis and dilatation and kinking of the ureter. The dilatation varies greatly. The lesser and medium grades will entirely recover, but the more severe grades with atony of the pelvic musculature only partially recover.

6. In women having borne children, a dilated pelvis and ureter, especially if the right side, may be a normal condition, the kidney forming normal urine and having a normal function.

7. The colon bacillus is usually the infecting organism, but others may occasionally be primary or engrafted on the colon infection.

8. The early diagnosis and treatment of pyelitis of pregnancy may be the means of avoiding serious, if not irreparable, damage to the kidney.

9. Pelvic drainage and lavage is of marked value, adding little, if any, risk when properly done.

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FAILURES AFTER GASTRO-ENTEROSTOMY TURNED TO SUCCESS BY THE KNOWLEDGE FURNISHED BY X-RAY EXAMINATION*

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FROM time to time the operation known as gastro-enterostomy turns out a complete failure. The reason for its failure is not easily found. An excuse for the failure has been stated to be a vicious cycle; i.e., the food passes out at the opening and instead of going on towards the lower end of the bowel it returns to the stomach through the pylorus carrying bile with it, and soon after, the patient vomits and brings up bile. This is purely a theory and has no definite roentgen-ray observations to bear it out. A better explanation is that afforded by roentgenogram, when it is seen that the stomach does not empty itself, though it makes violent efforts to do so, and finally ends by rejecting all its contents. A little bile in the vomitus does not prove that there is a vicious cycle. One sees frequently during routine examination of the stomach the food forced through the pylorus and the cap filled up and this cap's contents pouring back into the stomach. In other cases one sees the food in the second part of the duodenum moving to and from the cap. It requires no stretch of the imagination to think that during the violent effort of vomiting some bile was forced out of the duodenum and into the stomach, which later was found present in the vomitus; and that thus a vicious cycle was inferred.

I have looked for the vicious cycle with *x*-rays and have never been able to see it. What I have seen, however, in cases of vomiting following gastro-enterostomy is that there is gastric delay and that vomiting is due to the stomach being unable to get rid of its contents any other way. I have never seen a case of vomiting where the gastro-enterostomy opening was near to the pylorus, but only in cases where the opening was far away from it. When one begins to examine a case of gastro-enterostomy one should sacrifice the plate for the information given by the screen. The main mass of useful information is obtained in the first thirty seconds after the patient swallows the barium. He is examined in the upright nostro-anterior direction. He comes with an empty stomach and no barium in the intestines. As soon as the barium reaches the gastro-enterostomy opening a little goes through and is seen entering the small intestine.

The patient is then at once turned to the left lateral position and the examination is continued, to note the position of the gastro-enterostomy opening from the side. It may be said to be an anterior or a posterior gastro-enterostomy by the surgeon, but it is usually very near the greater curvature when the patient comes for roentgen-ray examination.

In all cases whether successful or not, barium escapes almost at once. It may then continue to rush out, till, in about ten minutes, the stomach is empty. In such a case the stomach is practically functionless and assumes an appearance accordingly; that is, it is small and shrinks in size upward towards the cardiac end, so that the gastro-enterostomy opening becomes its most dependent part, and the stomach becomes practically a tube through which the food passes without gastric digestion. I have seen several such cases. One told me that he had gained seventy pounds after his operation, seven years before, that he was in perfect health and never felt as if he had a stomach. Too quick evacuation of stomach contents is no bar to digestion, as the small intestine can do the work.

Another form of successful case is that in which one sees the barium escaping quickly at first and later quite slowly. It seems that the gastro-enterostomy has a sphincter action and allows the food to escape at nearly the same rate as the py-

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lorus does. It should be distinctly understood that the food does not escape from the stomach by drainage, but only by tonus and peristalsis. If, therefore, there is a gaping gastro-enterostomy opening in the stomach and no peristalsis and no tonus, the stomach will not lose any of its contents any more than a rubber bottle with the cork out will lose its contents when turned upside down in a water bath. Barium would drain out, but the bulk of our food is lighter than water, therefore does not drain out of a stomach.

The third kind of gastro-enterostomy opening is that which at first lets the barium escape, then allows no more to pass. It is usually found too near the cardiac end of the stomach, so that the waves of peristalsis either do not reach it, or begin just at its location. This kind of case benefits from roentgen-ray examination. A description follows:

Case I. Female, brought to me in an ambulance, so weak she could hardly stand for examination. She had vomited after every meal for three months following the operation of gastro-enterostomy. She was wasted and pale. Having found out the exact position of the opening by seeing the first rush of barium through it as the drink descended to the lowest part of the stomach, having examined it anteroposteriorly and laterally, and seen that the opening was nearer the greater curvature and above the peristaltic part of the stomach, I told the patient to lie on her left side, and with much pleasure I saw the stomach begin to empty. She was instructed to lie on her left side for an hour after every meal. After about a week her husband came to me in delight to tell me that she had not vomited again. Three months after, she had vomited only twice; once when she had not followed instructions and once when she had been much worried by other causes.

Case II. Female, symptoms similar to those of Case I. To my disappointment I found that the food did not escape when she lay on her left side. While I watched her, thinking what to do next, she rolled over on her stomach pressing on a doubled blanket as she did so. At once there was a squirt of barium through the gastro-enterostomy opening. I made her do this time after time till the stomach was nearly empty. I then told her to lie on her left side after each meal, place a pad for herself on which to roll over, and continue to move as she had been doing on the *x*-ray table. The result was that she ceased vomiting from that moment, and grew strong and well. I heard from her after about six months and she was then in the best of health.

There is only one indication for gastro-enterostomy, namely, retention of food in the stomach for seven hours or more. The contraindication is a duodenal ulcer without obstruction, because the contents of the stomach prefer to go out through the pylorus when it is patent rather than through a gastro-enterostomy. A gastro-enterostomy does not close after it has been established. I have seen only one case which refused to allow barium to pass; but at operation it was found still patent, with adhesions so firm around it that nothing could pass it.

When a gastro-enterostomy opening is functioning well and the patient continues to have pain and no gastric delay, an ulcer at the opening should be suspected. Tenderness on pressure over the gastro-enterostomy tends to confirm the diagnosis. There is no sphincter developed in a gastro-enterostomy. It is the tonus of the stomach which produces an effect which simulates the presence of a sphincter.

There is little or no peristalsis seen when escape takes place freely through a gastro-enterostomy.

SUMMARY

1. Vomiting continuing for weeks after a gastro-enterostomy is usually due to retention of food in the stomach.

2. The gastric delay is due to the stoma being placed too far from the pyloric end.

3. Roentgen-ray examination not only may disclose the cause, but provide the remedy.

4. *First* case of vomiting after every meal for three months following gastro-enterostomy cured by lying on left side after meals. *Second* similar case cured by lying on left side and rolling over a pillow on stomach.

A STUDY OF RICKETS WITH REVIEW OF RECENT LITERATURE

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RICKETS is a chronic acquired disease, occurring most commonly during the first two years of life. Its etiology has not been established, but various hypotheses have been suggested to account for its occurrence. Among the causes suggested are a deficiency of fat, an excess of carbohydrates (or a combination of both), a deficiency of calcium, heredity, poor hygienic conditions, etc.

Howland[1] says, "It is roughly proportional to the density of the population and it seems directly dependent upon bad food, lack of fresh air, poor care and filth. The difference between the disease in the well-to-do and the poor is in its severity." Findlay[2] carried out rather extensive research into the conditions,—hygienic, dietetic, etc.—of actively rachitic and non-rachitic children belonging to the same social class. The most important observations in order of significance were improper housing, lack of facilities for fresh air and imperfect parental care. McKay's[3] observations confirm the general belief that rickets commonly occurs in children receiving a diet high in fat and low in carbohydrates. Howland thinks breast-feeding usually protects against severe rickets, though he has seen some of the most severe types in breast-fed negro babies. Artificial foods tend to produce the condition.

Winters[4] believes tuberculosis, syphilis, poor hygiene, etc. predispose but do not cause rickets. He says, "The sole essential factor that can cause rickets is food. Under the worst hygienic conditions, a child nursed exclusively by a healthy young mother never becomes rachitic." Pritchard[5] thinks that practically all varieties of malnutrition occurring during infancy and early childhood tend to terminate in rickets, provided they are sufficiently severe or long enough continued.

Braden-Birks[6] reports a case weighing 10 pounds and 7 ounces at 17 weeks having symptoms typical of rickets, in spite of the current belief that the disease does not occur so young.

Mellanby[7] in his recent investigations on puppies states that the probable cause of rickets is a diminished intake of anti-rachitic factor, which is either identical or somewhat similar to fat-soluble vitamin. A. Hess[8] does not believe that rickets can be caused merely by a deficiency of fat-soluble. A. Hess and Unger[9] say that "the fat-soluble vitamin is not the controlling influence; that infants develop rickets while receiving a full amount of the principle, and do not manifest signs although deprived of this vitamin for many months at the most vulnerable period of their life."

The recent experiments of Sherman and Pappenheimer[10] show that "on the particular diets used rickets uniformly appeared in the absence, and was uniformly prevented by the presence, of the added potassium phosphate, but this does not imply that in these cases the cause of rickets was necessarily a deficiency either of potassium or phosphorous."

McCollom[11] and his associates from their recent experiments with a series of faulty diets fed to rats say: "It seems possible to infer from our experiments that the development of rachitic-like changes in the rat, induced by diets deficient in fat-soluble A and the phosphate ion can be prevented by the addition to the diet of phosphate containing salts; and that conversely for rachitic changes to develop in the presence of a deficiency of fat-soluble A in the diet, the diet in other respects being optional, a low content of the phosphate ion is essential. The experiments indicate further that in the production of rachitic-like conditions in the rat,

fat-soluble A cannot be the sole factor concerned . . . . Studies on the effects of feeding cod liver oil to rachitic children have led to similar conclusions."

Most writers classify as early evidence of rickets such symptoms as sweating of the head, muscular weakness, laxity of ligaments, delayed dentition, spasmodic manifestations, tendency to catarrhs and the tossing of head from side to side, often rubbing the hair off the occiput. The flabbiness and softness of the skeletal muscles is most striking. The abdomen is often prominent. The child is pale and may have anemia of the secondary type.

According to MacCallum,[12] the epiphyses of the knees, ankles and wrists are much enlarged, and swelling occurs at the costochondral junction. Scoliosis, fractures and a peculiar flattening of the pelvis are due to a general softening of the bones. In normal bone, the outer surfaces of the line of ossification is sharp, even and narrow. In rickets it is replaced by a wide irregular band of rather gray translucent tissue. The enlargement of the epiphysis is due to sluggish ossification rather than to the excessive production of cartilage. The output of calcium in the feces during the florid stage is high while the proportion is lowered in the urine. Healing is preceded by a hyper-retention and a relative increase in the output of calcium in the urine. The proportions are normal after healing takes place. The deficiency of calcium is an important factor. Some deem it necessary to assume there are specific changes in the bone-forming tissues which make them unable to retain the calcium.

FIG. 1. Anteroposterior view showing scoliosis due to rickets.

FIG. 2. Lateral view showing scoliosis due to rickets.

Rickets probably affects all the tissues of the body but the chief pathological lesions are represented in the long bones. The normal bone consists of 63 parts of inorganic and 37 parts of organic matter. Winters[4] states that rachitic bone is composed of 79 parts of inorganic and 21 parts of organic material. Also that the specific gravity of rachitic bone is only ⅓ to ⅛ that of normal bone. He considers that "exuberance of cartilage cells and sparsely scattered islets are the anatomical signs of rickets."

FIG. 3. Note the rather large shadow normally cast by the epiphyses before calcification has taken place.

Rickets shows itself in the skull by delayed ossification between the parietal and occipital bones. Many writers believe that craniotabes, which manifests itself as round spots of localized thinning in the skull, is an early symptom of rickets.

Elsasser[13] first published his observations on craniotabes in 1843. Schwartz[14] examined 4,944 infants of which number 734 (approximately 15 per cent) showed evidence of soft spots during the first months of life. After one year the number decreased regularly as the children grew older. Examination of 760 infants by Levinson[15] showed 162 with craniotabes (21 per cent). In his cases, there was no relation between craniotabes and the general condition of the infants, most of the children with craniotabes having been in good condition.

FIG. 4. Shows flaring and widening of the diaphyses, rather marked cupping of the epiphyses in rickets, and slight bowing of the shaft. A very large cartilage is seen, especially around the knee-joint.

Hatfield[16] believes rickets may be a very important causative factor in the development of malocclusion. Dentition is delayed and the deciduous teeth are lost early. There may be faulty development of bones of alveolar process, and of the bones of the mandible and maxilla.

In the thorax the enlargement of the costochondral junctions, the so-called "rachitic rosary," has long been recognized. Of 4,944 infants examined by Schwartz,[14] 35 per cent showed beading of the ribs, and 13 per cent of these during the first month. He believes practically all infants will show this condition if examined regularly during the first year. Hess and Unger[17] found that beading of the ribs occurs very often in cases of infantile

scurvy, and disappears rapidly with the recession of the other symptoms, when an antiscorbutic food stuff is given. Park and Howland[18] have published observations on 22 negro babies showing marked evidence of rickets in the thorax as well as other parts of the skeleton. The manubrium

The writers describe the roentgen-ray findings as characteristic. The ribs are slender, bent, porous and have lost their normal inclination and parallel arrangement. Fractures are difficult to demonstrate. Scoliosis is visible when present. The heart appears enlarged for the size

FIG. 5. Osteogenesis imperfecta. Note the greatly enlarged cartilage around the knee-joint below the femur and above the tibia. In addition to the fracture shown in the middle third of the femur, there was a total of ten fractures in the long bones in this case. There is some periosteal proliferation and evidence of callous formation about the fractures. The bones show diminution in density, apparently due to absence of lime salts. The epiphyses are widened and irregular.

FIG. 6. The bones are thin with rather coarse trabeculation. There is marked bowing of the shaft with thickening of the cortex on the concave side, and absence of periostitis. The epiphyses are widened and cupped with irregular, jagged edges. Cartilage is not visible.

is prominent and appears elevated, as does the whole chest. The deformities of the chest are often asymmetrical. The ribs were very soft and pliable in the autopsied cases. The forces bringing about the deformities they enumerate as follows: negative pressure existing during inspiration, elasticity of the lungs, the pull on the diaphragm, various voluntary muscles passing to the thorax from the abdomen and the neck, gravity and intra-abdominal pressure. These forces all work during inspiration, except gravity, and the normal thorax is able to overcome them. The lungs become small as a result of these deformities, and frequently atelectatic.

of the chest. Longitudinal shadows are seen on both sides of the heart, with indefinite outlines, and are caused by the atelectatic lung beneath the costochondral junctions. The costochondral junctions cast shadows when healing begins, and take part in the formation of the longitudinal shadows. The lungs have an uneven, hazy appearance external to the longitudinal shadows caused by the scattered areas of atelectasis. The characteristic roentgen-ray findings are mistaken frequently for tuberculosis.

The spine may show deformities such as kyphosis and scoliosis which are detected easily when present. The pelvis may show thickening of the crista ilii, as well as narrowing of the pubic arch.

The lesions of rickets are probably best

seen and studied in the extremities. The epiphyses of the lower end of the radius and ulna are often enlarged sufficiently to be apparent, and less often in the upper end of the bones and the humerus. The cartilaginous epiphysis of the knee is often prominent to palpation. The lower end of the tibia and fibula present quite characteristic changes. Enlargement of the femur is less frequent.

The most important changes are shown on the roentgenogram in the region of the epiphyseal line of the long bones and neighboring joints. The entire joint may be slightly swollen, hazy and cloudy. The limitation of motion, due to the painful joint, is partially responsible for slight atrophy occurring in the bone. Normally the diaphyseal end is smooth, clear-cut, sharp and narrow, while in rickets it spreads outward and its edges are irregular and jagged. The centers of ossification which normally should be readily seen are small and often absent. The process of ossification is delayed.

In reviewing a large number of plates we have observed that the epiphyses cast a shadow on the roentgenogram before calcification takes place. There is noted frequently an apparent increase in the size of the epiphyses as compared to the shaft end of the bone in rachitic conditions. We believe this shadow may be seen fairly constantly in plates of good quality, and may have some bearing on the diagnosis of rickets. These epiphyseal shadows are studied best in the knee joints.

There is often a white line extending transversely across the shaft, near the epiphysis, due to the deposit of calcium in the diaphyseal end of the bone as the result of proper treatment. The shafts of the long bones, more especially the lower extremities, are frequently bent, showing a thickening of the cortex on the concave side of the curve, whereas in syphilis the thickening is on the convex side.

Periostitis may be seen in rickets. The bones are weaker and more yielding, and deformities may be the result, such as knock-knees and bowlegs. Fractures may be incomplete and are single or multiple. Baetjer[19] has reported as many as 18 in a single case.

SUMMARY

Rickets is a chronic acquired disease occurring most commonly during the first two years. Many views have been advanced to account for its occurrence, among these, heredity, improper hygiene, infections of various natures, dietetic conditions, etc.

All the tissues in the body may be affected in rickets, but the principal pathological lesions are seen in the osseous tissues. The cranial bones may show changes in shape and delayed ossification. Scoliosis and kyphosis may be detected in the spine. Dentition may be delayed. Enlargement of the costochondral junction, the so-called "rachitic rosary," manifests itself in the chest. The ribs are bent, porous, slender and have lost their normal inclination and parallel arrangement. The lungs are frequently small and atelectatic. Periostitis may be seen. Fractures may be single or multiple, and are often incomplete. The cartilaginous epiphyses are enlarged and frequently show on the roentgenogram. The diaphyseal end of the shaft spreads outward and its edges are irregular and jagged. The most important changes radiographically are seen in the epiphyseal line of the long bones and neighboring joints.

In conclusion, I wish to thank Dr. George W. Holmes for his guidance and assistance in the preparation of this paper.

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HIGH TENSION ELECTRIC SHOCKS IN ROENTGENOLOGIC PRACTICE*

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THE scientific installation of roentgen-ray apparatus, to provide safety as well as efficiency, is of utmost importance to roentgenologists and to patients alike. It is also of vital concern to hospital authorities and to architects who design buildings or rooms where such work is to be done.

In many roentgen-ray laboratories, including the offices of physicians and dentists who have roentgen-ray machines, there has been too little thought devoted to the study of safety. Simple and well known laws which govern electric currents have been overlooked or disregarded generally by the manufacturers and installers of apparatus and by roentgenologists themselves.

ACCIDENTS

Our report of accidents covers six cases. All were due to grounds. In two cases the operator was grounded through the low tension wires of a foot switch (in practically all foot switches on the market today, the distance between the low tension wires and the operator's foot is so short that high tension currents will easily spark across). In three cases a concrete floor furnished the ground and in one case the patient was grounded through a grounded metal table. The source of the high tension current in five cases was unguarded high tension wires or tube terminals; in the sixth case the current jumped across a defective Coolidge transformer. The high tension current would not have injured a single one of these persons however, if the apparatus had been properly installed to afford protection against grounds. Although none of these accidents were fatal, there were a number of fatal accidents throughout the country last year, as reports heralded broadcast by the newspapers indicate. A perfectly justifiable apprehension on the part of the public is the result.

REPORT OF CASES

Case I. The writer was personally shocked from a high tension current by being grounded through a *concrete floor*. An assistant closed the switch to test tube

* Read before the Medical Society of the District of Columbia, Oct. 19, 1921. Owing to the forthcoming report of the Committee on Safety, portions of this paper have been omitted as covered in that report.

readings, while the *high tension wires* were being adjusted. A severe shock and some painful burns were received, but as the duration of the shock was short the effects were not very serious.

CASE II. In the service of a colleague, a 220 pound negro orderly approached too close to one of the *live terminals* of a transformer. He was standing on a *concrete floor* which furnished a ground. The shock he received caused the giant negro to crumple to the floor like a quivering leaf.

CASE III. A patient was being given deep therapy with 9 inch gap and tube overhead, while lying on a *grounded metal table*. He moved and was sparked from one of the *tube terminals*. This made him squirm into closer contact with the live wire. Fiery flames shot into his body from the tube terminal and inspired an awe, never to be forgotten. A clean cut hole was burned through a thick leaded rubber which was being used over him as protection against the roentgen rays.

CASE IV. At another time the writer accidentally came within sparking distance of a *high tension wire* while using a *foot switch*. The shock which resulted was felt for the most part in the leg resting on the foot switch. This foot switch was similar to those in general use, the low tension service wires being within sparking distance of the operator's foot. Thus low tension wires are excellent grounds for high tension currents and the foot switch was the cause of this accident.

CASE V. "Dr. F. V. M., was severely shocked through a *concrete floor* ground by the high tension current *breaking* across the *Coolidge transformer* to the Coolidge service wires. The doctor grasped hold of the service cable of this line to disconnect it as he saw the insulation burning. The high tension current then short circuited through his body to the concrete. He fell to the floor still holding the cable as he was unable to release it. It was several minutes before a nurse arrived who turned off the main switch. The doctor received numerous third degree burns on his back and hand from sparks to the concrete and to the cable which he was grasping" (Rohrer).

CASE VI. "Dr. S. C. was using a horizontal *metal fluoroscope* with a *foot switch*. An anesthetist was leaning over the metal fluoroscope and brought his leg into contact with the *high tension wires* beneath. The current passed through the body of the anesthetist to the table, then to the hand of the roentgen operator by way of the shutter levers and through his body to ground by way of the foot switch. Both men were thrown to the floor unconscious, but the circuit was broken by their fall and the shock was thus of very short duration and both men recovered" (Rohrer).

EXPERIMENTS

Our experiments were performed on young dogs and are presented herewith in tabulated form. In each experiment a dog was attached to one or both of the high tension lines. Ordinary insulated lamp cord was wrapped about him so as to form the necessary collar, belt or anklet electrodes. We used a 10 kilowatt transformer with both terminals developed, the secondary windings being grounded in the middle. A kilovolt meter and milliammeter were in circuit. There was a rectifying disk delivering unidirectional current to a Coolidge tube, a control consisting of a rheostat of twenty steps and an inductance selector of six steps. The range of voltage with rheostat out was from 40,000 to 100,000 volts corresponding to a spark gap of from three to nine inches.

In the *first* series of experiments the *dog was insulated* from all grounds and from the opposite terminal and his collar electrode was attached to either one of the high tension lines, first to the positive and then to the negative. In spite of the fact that his collar was charged with as much as 50,000 volts, he remained unharmed and comfortable throughout all of the experiments of this series. Thus coming in contact with one high tension line will not injure a patient if he is properly protected from grounds and from the opposite terminal. (See tabulated Exp. 1 and 2.)

In the *second* series the *dog was grounded* and at the same time attached to one or the other high tension line. He was grounded by being placed either on concrete or on grounded metal. In Experi-

ments 3 and 13 the dog was separated from the grounded metal table by about 2 inches of wood; at 9 inch gap the current burned a hole through the wood just as clean cut as though bored with a gimlet. In these and every other experiment of the series the dog was severely shocked or burned. (See tabulated Exp. 4 and 5.)

In the *third* series the body of the *dog formed a short circuit between the two high tension wires or the two terminals of a Coolidge tube.* The effects were even more severe than in the second or ground series. Grounding a dog that is being shocked between two terminals (Exp. 12) seems to lessen somewhat the severity of the shock, but nevertheless the dog is severely injured. (See tabulated Exp. 6 to 14.)

DEDUCTIONS

From the foregoing accidents and experiments and from the literature, we obtain many interesting and important data concerning the effects of high tension currents on animals, the sources of danger, and remedial measures which should be adopted.

EFFECTS ON ANIMALS

Heart and Respiration. Prevost and Batelli experimented broadly to determine the effects of electric currents upon the living animal. They state, "currents of sufficient amperage and of voltages measured in hundreds kill by cardiac fibrillation, voltages in thousands kill by respiratory paralysis." Our experiments show that currents sufficient to be of any use in *x*-ray work cause respiratory paralysis which lasts for nearly a minute after the current has been removed.

Current Time, Asphyxiation, Burns. In lethal electrocutions currents of about ten amperes at 2,000 volts cause respiratory paralysis and the current must be continued for seven to ten minutes. In other words *death is by asphyxiation* and the current must be continued until the heart stops beating. As the currents used in roentgen-ray work cause respiratory paralysis they will cause death if they are continued long enough. Current time is an important factor also in the *severity of burns* inflicted. A current lasting less than one second does not burn the animal appreciably even with all of the amperage and voltage which the transformer is capable of delivering under the conditions of our experiments (Exp. 11, 12 and 13); the respirations may be stopped, however, with currents of even less than one second duration (Exp. 13). In two seconds some burns were inflicted especially by the negative electrode, in ten seconds quite severe burns (Exp. 9), and in thirty seconds very severe burns indeed, even with the smallest amount of current which the transformer is capable of delivering—currents too weak to be of any use whatever in roentgen-ray work (Exp. 14).

Burns are produced, partly no doubt by contact of the skin with the superheated gases of the spark gap, partly by the resistance of the tissues to the current flow but chiefly by chemical action. Burns at the negative electrode, in the line attached to the filament end of the Coolidge tube, bleed freely and this is generally recognized to be due to alkaline action; burns at the positive electrode are charred and dry and do not bleed on account of the presence of acid.

Remote Effects on the Tissues. Tousey cities the case of a lineman who short-circuited two live wires carrying 5,000 volts at high amperage. The workman was not killed instantly but was severely burned and died about a week later. One of our dogs (Exp. 13) was shocked in every conceivable way and with all strengths of current within range of the transformer, but in no case for more than one second. He was not burned but was rendered breathless a number of times, yet he soon recovered and is now as healthy as any of the other pups of the litter that were not subjected to the experiments. Most experimenters believe that there is some form of tissue disorganization, but do not attempt to specify the nature of the changes, except the collection of acid and alkali at the opposite electrodes.

Effects Depending on Position of Electrode. When the electrodes are applied to the neck and body the effects are more severe (Exp. 6, 7, 9, 10) than when applied to the ankles (Exp. 8). The strongest

EFFECTS ON DOGS, FROM HIGH TENSION ELECTRIC CURRENTS USED IN ROENTGENOLOGIC PRACTICE

Series No.	(1) Dog Insulated		(2) Dog Grounded			(3) Dog Forming Short Circuit Between Two High Tension Lines								
Experiment No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Position of dog														
From grounds														
Insulated from grounds by air, inches	10	10	wood 2"	..	..	10	10	..	10	10	10	..	2 to 10	10
Grounded on metal	..	..	..	..	..	..	....	yes	....	....	....	yes	yes	..
Grounded on concrete	..	..	..	yes	yes	..	....	....	....	....	....	....	yes	..
Electrodes A = anklet, B = belt, C = collar, P = positive, N = negative.	PC	NC	PC	PC	NC	PC & NB	PC & NB	PA & NA	PC & NB	PC & NB	PC & NB	PC & NB	All	PC & NB
Switch settings														
Rheostat button No. (total 20)	9	9	9	5	10	5	10	9	10	5	20	10	5 to 20	2
Inductance button No. (total 6)	6	6	6	1	1	1	1	6	2	5	3	2	1 to 6	1
Readings														
Gap, inches, normal Coolidge tube in circuit	9	9	9	3	3	3	3	9	4.5	8.5	5.5	4.5	3 to 9	2
Milliamperes, normal tube in circuit	5	5	5	5	30	5	30	5	35	5	40	35	5 to 40	5
Gap, inches, dog plus tube in parallel circuit	9	9	0	0	0	0	0	0	0	0	2	0	0 to 2	0
Dog, milliamperes (limit of meter 150)	5	5	?	?	?	90	150+	150+	150+	100	150+	150+	150+	?
Duration of current, seconds	30	30	2	1	3	3	2	2	10	6	½	1	½	30
Effects upon dog														
Harmed, yes or no	0	0	yes	yes	yes	yes	yes	yes	yes ++	yes	yes	yes	yes	yes much +
Breathless, seconds	0	0	30	0	40	30	35	0	40	40	0	0	0 to 40	0
Unable to crawl, minutes	0	0	3	0	5	3	4	0	5	5	0	0	0 to 5	0
Burns, at positive electrode	0	..	sl.	0	..	0	0	0	sl.	sl. bad	0	0	0	yes bad
Burns, at negative electrode	..	0	..	..	sl.	sl.	sl.	sl.	yes	yes	0	0	0	very

currents applied to the ankles did not cause respiratory paralysis, but they were of short duration—two seconds.

SOURCE OF ELECTRICAL DANGERS

Martin states that "currents of high voltage and high amperage are always dangerous; currents of high voltage but low amperage are not necessarily fatal unless the subject forms a *short circuit to ground or between two high tension wires.*" Currents used in roentgen-ray work are of very high voltage, but of amperage measured in thousandths of an ampere—very low. Accordingly the source of high tension dangers in roentgenologic practice are: (1) grounds and (2) unguarded wires and tube terminals.

Grounds. The problem of grounds and how to avoid them is not as simple as one might suppose. It requires a consideration of not only what will happen when everything goes right, but also what mistakes the operator is liable to make, what movements it is possible for the patient to make, and what accidents may happen to the apparatus to cause a charging of low tension wires, switch handles and metal apparatus with high tension currents.

Purposeful Grounding of Apparatus. Many roentgenologists purposely ground detached overhead tube stands, fluoroscopes, switch control boxes and even metal tables. This is done to get rid of annoying static sparks and to deflect the high tension current to earth in case it becomes short circuited to the metal of the equipment. It must not be forgotten however that the high tension current may jump directly from wire or tube terminal to the patient or operator. Now if it is possible for a person so charged to come in contact with grounded metal all conditions will be fulfilled for him to receive a dangerous—perhaps fatal—shock. Such static sparks are never dangerous and the charging of metal equipment will do no harm as long as there is no possibility of completing the circuit.

Other Dangerous Grounds. In such a list there should be included radiators, heating and water pipes, electric conduits; electric light wires (in spite of the small amount of insulation around them) including *cable drop switches* for dim lights or other purpose; *all foot switches and their cables,* and transformer supply cables crossing the floor; in a word, all low tension wires and all grounded metal constitute conductors for high tension currents.

Concrete Floors as Grounds. It has been loosely claimed that dry concrete is not a good conductor. It has been our sad experience that concrete laid on the ground is an excellent conductor even when (apparently) perfectly dry. The floor where our experiments were performed is so dry that it is always very dusty. Yet a dog standing on this floor was shocked just as severely as if grounded on metal connected to the water pipe. Concrete floors above the first floor, are reinforced with metal; so the only safe rule is to consider all concrete a dangerous ground.

Tousey calls attention to the extreme danger from even small currents, when the subject is well grounded. He cites the numerous instances of persons being killed while taking a bath, if while immersed in the water, they catch hold of the lamp socket with wet hands and thus ground an ordinary 110 volt lighting current. During last summer two fatal accidents of this kind were reported in the newspapers. I have before me one of these reports. A girl of City Island attempted to fasten a bulb into a lamp socket in the basement of her home. She had just come from a swim. The water was dripping from her bathing suit and formed a pool on the concrete about her feet. Her dripping hands short-circuited the current to her body and she received a shock which proved fatal (as "low tension currents act upon the heart").

INSULATION

Guards Around High Tension Lines and Grounded Conductors. It should be made impossible for any person in the roentgen-ray room to come in contact with or approach within sparking distance of any high tension wire or tube terminal, or any grounded conductor including radiators, pipes, electric conduits, wires or switches. Guards should be built about such dangers. The guards should be made

of wood, fibre or other non-conductor. The air insulation thus obtained should always be more than the full sparking to ground capacity of the machine in use and not merely that for the work being done. For all radiographic machines, six inches is a safe air distance. Notwithstanding the fact that under ideal conditions an insulated person may touch one live wire without danger of serious injury, the likelihood of the circuit being accidentally completed is too great to take a chance. In any case a spark is received by a person until the potential of his body is equalized with that of the high potential source.

We find on the market today shielding screens of metal mesh, which are to be grounded and placed between the patient and the high tension wires. These constitute grounds, however, and as such are potential dangers in the same ways as other grounds. Most of the apparatus as made and installed today presents innumerable traps with circuits complete for high tension currents except at one place. The body of the operator or patient or a piece of stray metal furnishes the needed link, and a dangerous accident results.

CONCLUSIONS

The sources of high tension electric dangers are:

1. Concrete floors in roentgen-ray exposure rooms.

2. Metal tables, tubestands, fluoroscopes, or switch cabinets within sparking distance of anyone who might approach high tension currents, especially if such apparatus is or may become grounded.

3. Any grounded conductor within the room or under the floor unless guarded. This includes all low tension wires, cables to main or Coolidge transformers, foot switches, swinging cables of light switches, all wires of lighting system or wires for any purpose, and radiators, pipes and conduits.

4. Unguarded high tension lines and tube terminals.

The writer wishes to take this opportunity to thank Dr. C. A. Pfender, Professor of Roentgenology at Georgetown University, for kindly advice and assistance; also Dr. J. A. Gannon and Maj. W. Patterson of the Washington Asylum Hospital for the facilities afforded to do this work.

A NEW APPARATUS

BY CHARLES M. MING, M.D.

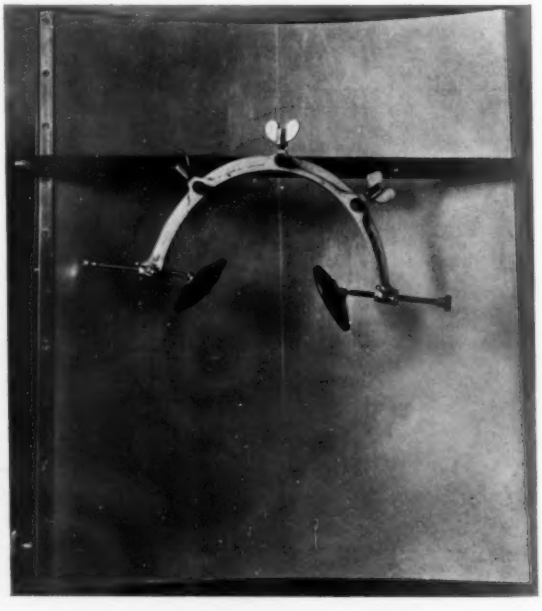
OKMULGEE, OMAHA

THE accompanying illustration depicts an immobilizing device designed by myself and found to be most satisfactory for complete fixation of the head in roentgenographic work.

The apparatus consists of a heavy flat iron bar which is bent to form a right angle at one end. To the other end there is affixed an adjustable clamp. This is secured with a winged nut. When clamped into place the bar is quite rigid. The headrest is attached by means of a bolt inserted into a hole which has been drilled in the center of the bar.

My apparatus is fitted on a Victor Potter Bucky diaphragm using a Kelley-Koett headpiece. Straps, rubber bags, etc. are thus eliminated and the cone need not touch the head.

Bag compression can be used if desired.



STANDARDIZATION OF THE MEASUREMENT OF TUBE POTENTIAL*

BY FRANK RIEBER

SAN FRANCISCO, CALIFORNIA

IN measuring the radiation given off from an *x*-ray tube we can do one of two things. We can measure what comes out of the tube in the form of *x*-rays. Or we can measure what we put into the tube, in the form of electricity, and then, from our experience with this tube, we can *predict* or estimate what is coming out of the tube in the form of rays.

The first method—that of measuring the rays themselves—was at first tried in various forms with pastilles, radiometers, and other measuring instruments. The Coolidge tube had not been introduced for therapeutic purposes at this time, and the gas tubes which were used were extremely unstable.

The various radiometer measurements did not check accurately in all cases with the therapeutic results. Their use was continued only because it was so thoroughly difficult to maintain a gas tube in constant operation long enough to make a measurement of the electrical energy being put in.

The advent of the Coolidge tube has resulted in a great decrease in the use of direct methods of measuring the rays. We can now set the electrical input at any desired value, and maintain it there indefinitely to as great a degree of accuracy as we may require.

It has therefore become very much more convenient to refer to radiation in terms of the milliampères passing through the tube, and of the potential or voltage impressed across the tube.

It must not be forgotten, however, that the choice of this method is one of *convenience*, and we must expect to sacrifice a certain degree of accuracy in determining the quantity and quality of our radiation when we use such measurements.

When we speak of input in terms of milliampères and kilovolts, or, as is more frequently done, milliampères and parallel spark gaps, we are defining two characteristics of the electrical energy we are putting into the tube.

If we are applying electricity to the tube in the form of a definite and *constant* potential, giving rise to a definite and constant current flow, the input to the tube becomes a simple electrical quantity and can be defined in terms of its two dimensions—potential and current.

If, however, we do not excite the *x*-ray tube at a definite and constant electrical potential, we make it impossible to define the electrical energy which we put into the tube accurately with *two dimensions only*. For example, an *x*-ray tube excited by a pulsating current is not excited at any one potential only. At some time during the pulse the tube has impressed on it every possible value of potential from zero to the very maximum or crest value.

In other words, where the electrical energy applied to the tube is pulsating, we are forced to deal with three factors if we wish to describe the energy we are putting into the tube. These three factors are potential, current and *wave form*.

So far we have merely predicted what *might happen*. As a practical matter, we often find instances of two machines which, if they are both operated at the same spark gap and the same milliampèrage, will produce entirely different results from the same *x*-ray tube.

There are only two possible explanations for this discrepancy. Let us deal with the first and dispose of it. It might be that the measuring instruments on one machine, namely, the milliammeter and spark gap, do not coincide in reading with the measuring instruments on the second machine.

We can easily check up this factor by taking the identical milliammeter and spark gap we used for measurements on

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 26–28, 1922.

the first machine, and transferring them to the second machine. We can also use the *same tube*, ruling out possible changes from this source.

If now we deliver to the tube from the second machine the same milliampèrage at the same parallel spark gap that we used on the first machine, and if we then find that the radiation obtained with the second machine differs remarkably from that obtained with the first machine, we can assume that *something else* which we *have not measured* has caused this difference in radiation.

As a practical matter, this test has been performed a number of times by different people. In many cases, they have established the fact that the two machines in question, for some reason, produce different radiation from the *x*-ray tube when the electrical energy as measured by the spark gap and milliammeter was identical and in some cases the radiation was delivered from the identical *x*-ray tube.

The explanation for this difference that has ordinarily been given is that the two machines delivered a different "wave form." This explanation is undoubtedly correct, but until we understand exactly what we mean by different wave forms, and until we understand fully the magnitude of the possible errors that may be caused by such differences, we are in danger of making grave errors when we use milliampères and spark gap as a universal measure of *x*-rays.

If we were putting uniform direct current into an *x*-ray tube, the whole matter would be simple. We know what direct current will do under certain conditions to a fair degree of accuracy.

For example, we know that a tube excited on direct current gives off rays which vary in intensity in direct proportion to the milliampères passing through the tube.

We further know that the quantity of radiation *is not* related in *direct ratio* to the voltage or spark gap. If we apply double the potential or spark gap to a tube, we will much more than double the quantity of radiation which leaves the tube, and we will increase its penetrative ability as well.

As we have said, the use of direct current on a tube would greatly simplify matters. We could be perfectly sure that with the same milliampèrage and the same potential or spark gap, we would get the same results. Direct current is a simple quantity and can be measured in terms of the two dimensions of current and potential. It has no possible third variable factor which could exert an influence on the tube.

When we come to excite an *x*-ray tube from any of the ordinary *x*-ray machines, however, we get into a very different problem. The electrical pressure or potential delivered from one of these machines comes in a series of pulsations. That is to say, we are not applying a steady pressure to the tube all of the time, but, at intermittent intervals, we are applying a pressure which gradually rises from zero to a maximum and then gradually sinks again to zero.

If we were able to take a large number of very rapid successive measurements of the potential in a single such pulse, while it was rising from zero and falling again to zero, we could then plot these measurements and get a curve in which the ordinates would represent potential and the abscissae would represent time.

We can readily take a record of pulsating potentials of this nature with the oscillograph. However, with the potential and current used in exciting an *x*-ray tube in therapy, oscillograms of this nature are not made without extreme difficulty. It is certainly not a practical matter to use an oscillograph in an *x*-ray laboratory for standardizing apparatus.

Let us therefore confine ourselves to considering what probably happens when such a pulsation of potential is applied to the *x*-ray tube. Let us further consider what, if anything, we can find out about such a pulsation with a milliammeter and a "spark gap" or a milliammeter and a spark meter.

It will simplify the discussion to dispose first of the milliammeter. When a pulse of potential of the type we have mentioned is applied to an *x*-ray tube, it causes a corresponding pulse of current to flow through the *x*-ray tube. We know that the milliammeter gives us a measurement of the combined effects of all the varying values

of current which go to make up such a current pulse.

We know further that the quantity of *x*-ray is rather closely dependent on the milliampèrage flowing through the tube. We can therefore be reasonably sure that the total milliampèrage passed through the tube represents quite accurately the total radiation delivered from the tube. This holds true, of course, if other conditions such as wave form and potential remain equal.

We can now narrow our attention to measurements of the potential applied to the tube, as this seems to be tied up in some way with the observed discrepancies between different machines, and between the results of the same machine with different settings.

Considering first the spark gap measurement, and the kilovolt meter or spark meter measurements, let us see what they really tell us about the pulsating potential we are applying to the tube.

The spark gap tells us *only one thing*, namely, the *maximum value* to which this potential rises. A measurement made with the spark gap is like measuring the pressure of steam in a boiler with a safety valve. If the safety value is set to blow at 100 lbs., the steam pressure can be 70, 80, 95, 99 lbs. or any other value less than a hundred pounds, and the safety valve will tell us nothing about it. But if the pressure ever exceeds 100 lbs. even momentarily, the safety valve will operate.

This is the function of the spark gap. All it can tell us is that at some part of each potential pulse, the potential reaches a value sufficient to break across the gap. It cannot tell us *how long* the potential stays at such a value. Further, it cannot tell us what the potential was doing during all of the rest of the pulse.

We might have had, for example, a very low potential during the entire duration of the pulse, and that potential might have shot up for a very brief instant to a value sufficient to break across the gap. The *x*-rays delivered from the tube when it was acted upon by this pulse would most of them have been generated when the potential was at a fairly low value. Very few *x*-rays might have been generated during the brief time when the potential shot up to a high value and discharged across the gap.

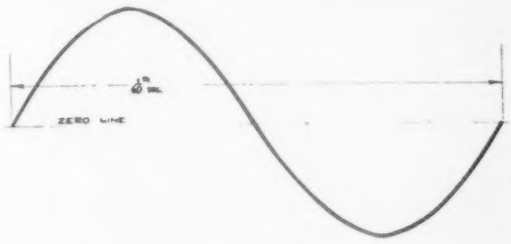
Nevertheless, if we trust the spark gap under these conditions, and assume that the value of the potential applied to the tube is fairly represented by the sparking distance of the gap, we may over-estimate the radiation from the *x*-ray tube by two or three times.

The kilovolt meter, or spark gap meter, on the other hand, measures an *entirely different thing*. It gives us the *mean effective value* of all of the potentials in a pulse. In this respect, it corresponds to the milliammeter.

The kilovolt meter would be a very beautiful means of determining the combined effects of all of the potentials existing in a pulse, *provided* the radiation from the tube varied directly with the potential. But unfortunately, the higher potentials have a much greater power to produce radiation than the lower potentials. And the kilovolt meter is unable to tell us anything about *what proportion* of the total pulse consists of fairly high potentials. It can merely give us the combined effects of all of them.

A simple illustration will make this matter very much clearer.

To facilitate an explanation of what wave form is, and why it effects the production of *x*-rays, a few illustrations are given.



COMPLETE CYCLE OF SINE-WAVE ALTERNATING POTENTIAL REPRODUCED FOR REFERENCE

1

These illustrations are *not* taken from actual oscillograms of alternating current. They are merely sketched to illustrate the effects of certain changes. In some cases the actual magnitude of these changes has been exaggerated in the drawing in order to make the explanation more obvious.

Referring to Figure 1, we have here a

sine wave of alternating potential reproduced for reference. The meaning of this curve is so generally known that it need not be dwelt upon in detail here. It merely shows a potential or electrical pressure which increases from zero to a maximum and then decreases to zero in a smooth and regular fashion, subsequently reversing its direction and increasing to a negative maximum, and then again decreasing to zero. Such a complete curve, consisting of a smooth pulsation of potential in one direction followed by a smooth potential pulsation in a reverse direction, is called a cycle of alternating potential. Sixty cycle current—the most widely used commercial frequency—employs sixty of these complete cycles of potential in each second.

Referring to Figure 2, we have a sketch showing what probably happens to such a

FOUR ARM RECTIFIER IN CLOSE ADJUSTMENT WITH AUTOTRANSFORMER CONTROL

2

sine wave of potential when it is passed through a transformer and a synchronous rectifier having long arcs of contact.

It will be observed that both pulsations are in the same direction. The first function of the rectifier, therefore is seen to be a reversal of every other half cycle of potential, so that all of the pulses are passed out in the same direction. Looking at Figure 2 more closely, however, we see that these pulses of potential are *not accurate reproductions* of the sine wave form, which is dotted into the drawing for reference. The reason for this is that the rectifier does not make contact during *all of the wave.*

In other words, the potential delivered by the transformer rises somewhat above the zero value before the rectifier permits the current to flow out through the tube. After this current has started to flow, however, it continues to do so smoothly and evenly until the rectifier has rotated through the entire arc of contact, and attempts to interrupt the circuit. At this point the tube potential will be seen to drop off below the true sine values. This is due to the fact that the electricity is now transmitted over a considerable distance in the air in the form of a spark, in the rectifier, and this spark does not conduct electricity very well. Consequently the potential drops more rapidly than it would have if there had been a good conducted path.

Turning now to Figure 3, we see in somewhat exaggerated form the effect of

FOUR ARM RECTIFIER WITH TOO MUCH CLEARANCE

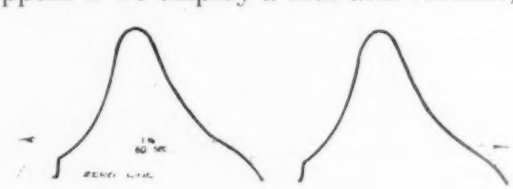
3

poor adjustment in a similar rectifier. If the rotating arms do not come very close to the stationary arcs of contact of such a rectifier, the electrical current is forced to pass across a relatively long air gap at all parts of the cycle, in the form of electric spark or arc.

Such a spark is a very unstable affair. If the tube is drawing a *large amount* of current, it will conduct it fairly well. If the tube is drawing a *small current*, on the other hand, it will conduct it with great difficulty.

As a general thing, a long sparking path of this type predisposes an electrical circuit to *surges*, or transient and rapid vibrations of electric potential above and below the smooth normal contour of the fundamental sine wave.

Turning to Figure 4, we see what happens if we employ a four arm rectifier,



FOUR ARM RECTIFIER IN CLOSE ADJUSTMENT WITH RHEOSTAT CONTROL

4

of the same type illustrated in Figure 2, but with a rheostat control instead of an auto transformer control. (It is assumed

that both machines are operating Coolidge tubes.) The apparent resistance of a Coolidge to a high potential discharge cannot be expressed in simple terms. The higher the potential, the higher the resistance of such a tube to the passage of current. The result is a deformation of the smooth wave form into approximately the shape illustrated.

Let us turn now from the four arm type of rectifier (or, for that matter, any rectifier employing a long arc of contact) to the customary disc type, where the contact is made abruptly during a small portion of the highest part of the potential wave.

Figure 5 gives an idea of the performance of such a rectifier operating a Coolidge

5

tube on a rheostat controlled machine. The shape of the wave form illustrated is due partly to the short arc of contact, partly to the combined effect of the Coolidge tube and the rheostat control, and partly to the surges excited by the abrupt making and breaking of the circuit when in a condition of stress.

Regarding *surges*, there is probably no better way of illustrating their presence than to refer to two commonly observed phenomena. If the operator of an *x*-ray machine closes his exposure switch, thereby passing a moderate current through his tube, and then gradually shuts down his spark gap, a spark will eventually result. The length of this spark is commonly taken as a measure of the potential applied to the tube.

If now, this gap is opened to a point where it will not spark while the tube is running, it *may be made* to pass, at will, merely by opening and closing the exposure switch. Whenever we close this switch, we throw current *abruptly* into the circuit, and create a surge, or "whip-crack" effect which temporarily increases the potential to a point where it will pass across the spark gap.

Another common observation indicating the presence of these transient potentials is the fact that when operating a rheostat controlled machine at a light load, the spark gap will, when gradually closed, flash over with a light scattering discharge. When approached more closely, this discharge becomes an arc or flame, which is generally regarded as the *true* measure of the applied potential.

This simple test is sufficient to show, that, even with a crude instrument like the spark gap, there are *two* observable values of tube potential. The question can be logically raised—*which of these values* shall we take to measure the *x*-ray, and why?

Having thus described a few of the many possible changes in wave form, let us now consider the instruments we have at our disposal for making measurements of potential, and *exactly* what each of these instruments tells us about this potential.

The spark gap is entitled to first consideration—largely on account of its age, and its long and faithful service in the cause. While it is a convenient measurement, we must not forget that an "inch of spark gap" does not really *define* an actual value of potential.

Four inches on one spark gap may mean the same potential that $4\frac{1}{2}$ *inches* mean on a slightly different spark gap.

A 4 inch spark gap measured on a machine in New York may denote an entirely different value of *potential* than 4 inches measured on the same machine after it has been transported to the mountains of Colorado.

Moreover, a 4 inch spark gap on a *dry day* may mean something quite different from four inches of spark gap when the air is saturated with fog.

In other words, our well-known and widely-used unit of potential is no more to be trusted for accuracy than a tape measure made of rubber elastic.

These vagaries are merely mentioned in passing. They cannot be avoided as long as the spark gap is used as a standard of measurement.

It is the intention of this paper, however, to deal with other factors affecting the spark gap as a means for measurement, and more closely related in the construction of the *x*-ray machine itself, rather than to external conditions.

A spark gap is presumed to measure the very *highest* value to which the potential rises during any single pulse. Below such values the air between the terminals of the spark gap is an insulator. Above this critical value, the air is "broken down" and the spark passes.

We have two forms of spark gap about which something is known, and which we can use approximately for measuring potentials. The first of these is the "point gap"—in practically universal use, but without any standard specifications for its construction.

The second of these is the "sphere gap," more recently adopted as the standard of potential in engineering work. The relative dimensions of these two gaps, and tables for their use will be given later.

There is one other commonly used method of measuring tube potential, namely, a *volt meter* connected to primary or secondary winding of the transformer, and furnished with various calibrations. Various of these were calibrated in the familiar units "inches of spark gap." Later, some of them have been furnished calibrated in *kilovolts*, in conformity with standard engineering practice for defining higher voltages.

Such a meter does not actually measure the *maximum value* to which the potential rises. It measures instead the *average value* of potentials in the entire pulse, taken as a whole.

Now, as we have seen, we are delivering from our *x*-ray machine a series of pulsating potentials. These potentials may assume almost any wave shape. There is no constant relation which can be established between the maximum value of any pulse and the average effective value of that pulse.

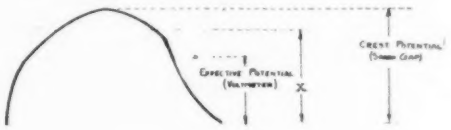
In other words, it would be very strange if there was any constant relation between readings of a spark gap and the readings of a kilovolt meter or a spark gap meter when used on different machines, or even when used on the same machine under different conditions.

The actual "*functioning potential*"—in other words, the particular potential in any pulse which is most effective in producing a quantity of *x*-rays—is unquestionably *lower* than the *maximum* value in any pulse, as determined by a spark gap. This effective "*functioning potential*" is also unquestionably higher than the *mean effective* potential as determined on a kilovolt meter or spark gap meter.

In other words, what we wish to find out with regard to the potential of a pulse is this effective "*functioning potential*" which we know to have a value somewhere between a volt meter reading and a spark gap reading.

And if we must choose between the volt meter and the spark gap as a means of measurement, it is desirable to know which of the two most closely approximate this effective potential.

To illustrate this more in detail, Figures 6, 7, 8 and 9 are given, showing the



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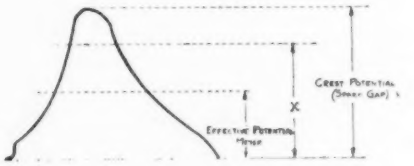

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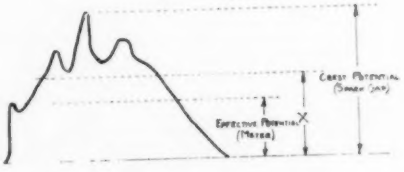

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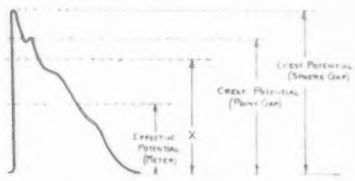
approximate values of volt meter and spark gap potentials in the four types of wave considered and also showing the probable value of potential which would most closely

describe or define the radiation coming from the tube.

The reason this potential is always less than in the *maximum potential* and bears no definite relation to it, is that this *maximum potential* is often—especially in the case of machines with short arcs of contact or poor adjustment—very transient in its nature. And the shorter such a pulse is, the less time it has to produce *x*-rays. It is possible for such a surge to be so short that the rays produced by it are negligible in proportion to the rays from the rest of the waves.

The reason that the effective "*functioning potential*" is higher than the effective potential shown on a meter is this. The lower values of potential affect the meter, but produce practically no *x*-rays, while the *higher* values of the potential affect the meter only in proportion to their magnitude, whereas the *quantity of x-rays* produced at these values increases *very greatly*.

Referring to Figure 9 it will be seen that two values are given for crest potential, one value being obtained by sphere gap and the other by point gap.



9

This fact deserves considerable comment. The sphere gap has been advocated at times as a possible standard for use in *x*-ray work.[1] It has even been advocated as a substitute for the point gap, on the grounds that it would give greater accuracy of results.

A sphere gap is extremely sensitive to very brief transient potentials or surges. A point gap is much less so, on account of the ability of the latter to absorb a very considerable amount of electrical energy existing in such a pulse by dissipating it as corona or brush discharge.

The sphere gap has no such safe outlet for brief high values of potential. It *must* get rid of the energy by sparking across—there is no other way.

This fact has been recognized and commented on by Coolidge and others.[2]

From the foregoing, we can conclude that if we are to define the output of an *x*-ray tube in terms of the milliampèrage passed through the tube, and the potential applied to the tube, we will have to do approximately this. We will have to devise an instrument or a measuring system which can be attached to our *x*-ray machine, and which will indicate for any applied pulsating potential, a value *less* than the *absolute maximum*, but *greater* than the *average value* indicated by a volt meter.

We can further state that for most wave forms, such a measurement would be fairly satisfactory if we could measure the *effective* or *sustained* value of the crest, at the same time *disregarding* any extremely *brief* surges or transient potentials which might be superimposed on the main wave form.

The accompanying diagram and illustrations describe an instrument which has been devised for this purpose. Briefly, its action consists in passing the pulsating primary current applied to the high tension transformer through a small rectifier and charging a condenser to the maximum potential of this current.

The condenser will then assume a value fairly accurately *proportional* to the maximum potential applied to the tube.

To prevent any brief transient surges from passing through this rectifier and reaching the condenser, a small reactance is placed in series with the leads to the condenser.

A direct current volt meter is then connected across the terminals of the condenser and used to indicate the effective current value to which the condenser has been charged.

On the assumption that this instrument would give fairly useful readings when applied to various *x*-ray machines, a number of tests were conducted. The results of

[1] W. D. Coolidge. A Summary of physical investigation work in progress on tubes and accessories. Am. J. Roentgenol., December, 1915, ii, 881.

[2] W. D. Coolidge. The radiator type of tube. Am. J. Roentgenol., April, 1919, vi, 175.

these tests are illustrated herewith in graphic form.

Figure 10 shows the calibration of the spark gap used. The source of electrical energy for this experiment was a machine making actual metallic contact during 85 electrical degrees—in other words, practically a pure pulsating sine wave form.

The A. I. E. E. specification sphere gaps were used, and the maximum spark potential which has been adopted for use with them was taken as a standard.

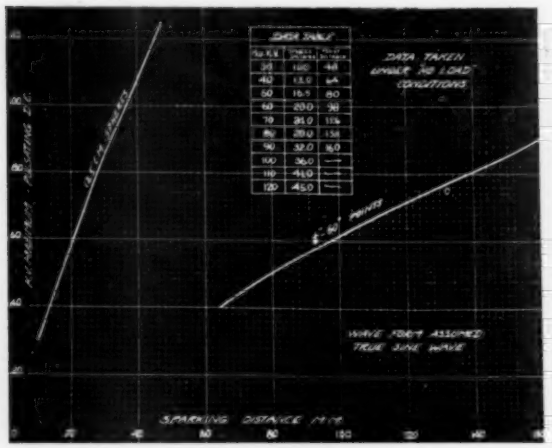


FIG. 10.

No standard specifications have ever been worked out for the so-called "point spark gap" commonly used in *x*-ray work. It was therefore assumed that ⅛ inch rod, beveled to a conical 60 degree point, and slightly blunted, would correspond to the rough average of the various spark gaps in common use.

The object in slightly blunting or rounding the point is that no user of *x*-ray apparatus takes pains to sharpen the points on his spark gap periodically, and they therefore become rounded through use. Hence it seems quite logical to start by slightly rounding such points.

Either of the curves given may be used (with appropriate reservations for inaccuracies) for translating spark gap readings on *x*-ray machine into *kilovolts* of potential. A *kilovolt* is a perfectly definite, measureable quantity. But an inch or a centimeter of spark gap is *emphatically not* a definite thing, even when measured with all possible precautions.

The point curve *must not* be confused in any way with another "standard" which is occasionally referred to in the literature, namely, the "*needle point gap*" formerly used by the A. I. E. E. as a standard of high potential. The values given in tables for this needle point gap apply only to a gap made with needles— and further they apply only for *alternating current*. They cannot be cross applied to *pulsating direct current* without errors which may reach as high as 50 per cent.

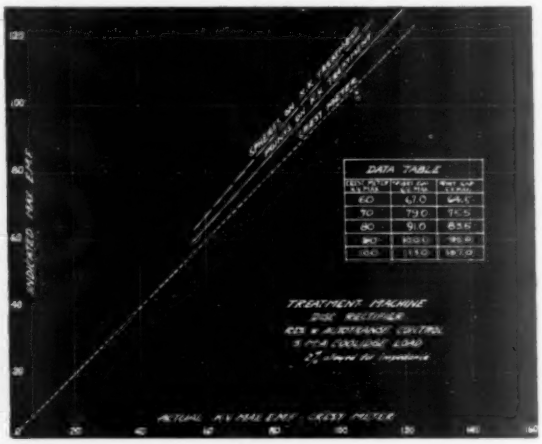


FIG. 11.

Proceeding with the description of the tests conducted, the crest meter was connected to the primary terminals of the high tension transformer of the *x*-ray machine under investigation, and calibrated by comparing its readings with the flash over value of a sphere gap connected to the *secondary winding* of the alternating current transformer. This sphere gap was connected on the alternating side of the rectifier, which was temporarily removed from the circuit in order to prevent any errors due to surges from sparks.

The crest meter was then adjusted by means of the variable resistance forming a part of the instrument, until the kilovolt reading of the meter corresponded to the indication on the sphere gap.

The rectifier in the *x*-ray machine under test was then connected and, with the Coolidge tube used as a load, various readings were taken.

Figure 11 shows the performance of a "treatment machine" employing a disc

rectifier with relatively short arc of contact. On account of the strong surges in such a circuit, the sphere gaps employed *indicated* a *higher* potential than that effective in making *x*-rays.

effect of surges in causing spark gap errors is somewhat less proportionately than that shown in Figure 11.

Figure 13 shows the performance of a "picture machine" with longer arcs of

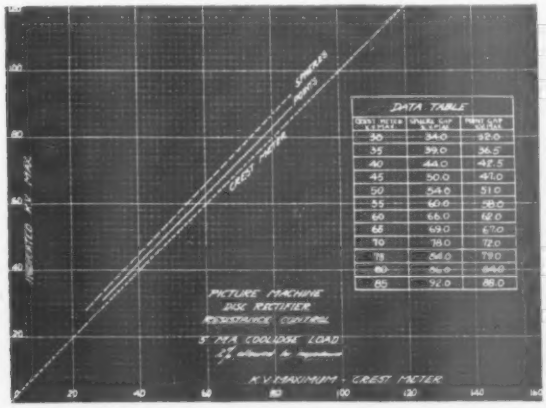


FIG. 12.

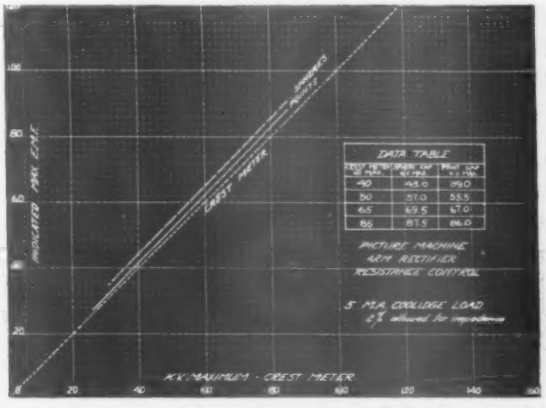


FIG. 13.

Further, the *sphere* gap, being *more sensitive* to surges than the point gap, indicated with this machine a higher potential than that from the point readings.

contact than those of the two preceding machines. This outfit was in fairly accurate adjustment, and it will be noted that the sphere gap, point gap, and crest meter are in far closer agreement on this account.

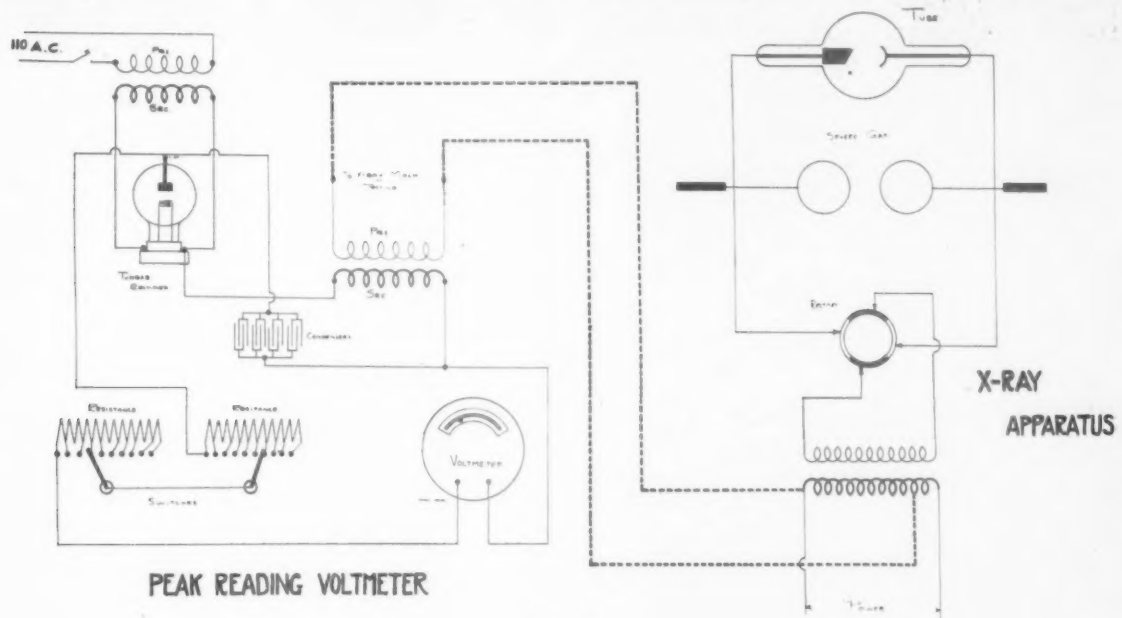


FIG. 14.

Figure 12 shows similar tests on a "picture machine" with the same type of rectifier. On account of the lower voltage, and the fact that a greater amount of resistance was used in the control, the

All these readings are *relative* only. It is possible to vary the discrepancies between sphere gap, point gap and crest meter *at will* by making slight changes in the circuit conditions.

During this investigation, the readings of the spark meter attached to these machines were also investigated, the general results being included in the following summary. It will be readily appreciated that, with the wide variety of such instruments in use, and the fact of any specifications for their standardization, no quantitative results of any value can be given here.

In closing, a *practical point* with regard to the comparative value of spark meters and spark gaps may be mentioned.

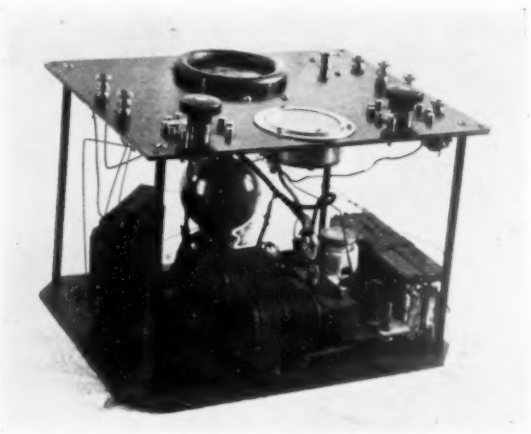
Outside view of crest meter.

A meter is a *continuous* index of what is happening, while a spark gap gives only the value of potential at a certain instant. The spark gap can, therefore, be relied on *only* if it is reasonably certain that the potential will *stay* at the value last measured. The meter, on the other hand, can be used with greater success on a highly variable supply line.

The useful results obtained from this work and applicable particularly to practical therapy may be briefly summarized as follows:

Point Gaps. Readings are often inconsistent, and must be repeated several times for workable results: With cross arm rectifier, carefully adjusted, average of all readings about 3 or 4 per cent higher than crest meter; variation between highest and lowest readings over 10 per cent; with disc rectifier, average of all readings 6 to 8 per cent higher than crest meter; variation between highest and lowest reading 15 per cent.

Sphere Gaps. Readings, almost as inconsistent as point gaps, must be repeated several times: With carefully adjusted



Inside view of crest meter.

cross arm rectifier, average of all readings about 7 per cent higher than crest meter. Difference between highest and lowest reading 8 per cent; with disc rectifier, average of all readings 12 per cent above crest meter. Difference between highest and lowest readings 20 per cent.

Kilovolt Meters. Only two were tested. As the results were desired for use in therapy, all tests were at 5 ma. except for a check at 20 ma. to determine effect of increasing load. Two per cent was allowed for impedence drop at 5 ma. load.

Resistance control of the *x*-ray apparatus permits distortion of wave form. The greater the resistance the lower the kilovolt meter reading for the same crest value.

Large gaps in the rectifier make the kilovolt meter read high.

Kilovolt meter readings are *consistent*, and a return to *the same*, or nearly the same, *rheostat* setting, the same milli-

ampérage, and the same kilovolt meter readings will give the same crest value.

RÉSUMÉ

A method of measuring significant tube potentials is presented.

The measurements taken indicate that the crest meter used responds to sustained peak potentials, but is unresponsive to surges and transients.

Spark gap readings, when investigated in comparison with this instrument, show inconsistencies, which are partially ascribed to surges.

The sphere gap seems to be more sensitive to surges than the point gap, and therefore, of less use in *x*-ray measurements. This statement applies for potentials up to 150 kv. Above this value, the spheres seem to be the best available method, in spite of their sensitiveness to surges.

Kilovolt meters cannot be relied upon unless calibrated against a number of point gap settings at the setting where used. They will then enable consistent return to that point.

Disc rectifiers give greater surges, and higher and more irregular gap readings for the same crest values than do arm rectifiers.

All rectifiers give much more consistent results when closely adjusted.

A METHOD FOR ROENTGEN-RAY DEMONSTRATION OF THE NASOLACRYMAL PASSAGEWAYS*

BY DON M. CAMPBELL, M.D., L.R.C.S. (EDINB.), JOHN M. CARTER, A.M., M.D., AND HOWARD P. DOUB, A.B., M.D.

DETROIT, MICHIGAN

STENOSIS, and the resulting inflammation of the nasolacrymal passageways, is a subject of paramount importance, not only to the oculist and rhynologist, but also to the unfortunate individual affected. Operations for the alleviation of this condition go back to the time of Galen, who first advocated breaking through the lacrymal bone and introducing a caustic to prevent closure of the newly-made opening. Only during the last decade, however, has any considerable degree of success been attained by the intranasal method of operation, and even during this time the operator has been seriously handicapped by his lack of precise knowledge of the size, shape and position of the nasolacrymal passageway and the point of obstruction in relation to the surrounding structures. We believe that this problem is greatly simplified by the use of the roentgen ray, following the injection of the nasolacrymal passageway with an opaque medium.

A normal nasolacrymal passageway presents the following:

1. The two lacrymal canaliculi, running from the free margin of the upper and lower lid. These run at first vertically for a short distance, and then turn at an angle to run a medial course converging toward the lacrymal sac. They then unite either in a common trunk to empty into the sac, or they empty separately.

2. The lacrymal sac is the upper dilated end of the nasolacrymal duct and is lodged in a deep groove formed by the lacrymal bone and frontal process of the maxilla. It is oval in form and measures about 12 mm. in length. Its upper end is closed and rounded, while the lower end continues as the nasolacrymal duct.

3. The nasolacrymal duct extends from the lower part of the lacrymal sac to the inferior meatus of the nose, being slightly narrowed at its lower extremity.

The methods employed in the past in the treatment of this condition may be divided into three groups:

1. The passage of large metal probes or curettes in an effort to relieve the stenosis. This method has never been entirely

* Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., Jan. 26–28, 1922.

satisfactory. This has been done on several of our patients a great number of times, one patient estimating that probes had been passed on him fifty times.

2. Those attempting the removal of the sac, or its destruction by caustic, in order to get rid of an infected or abscessed lacrymal passage. This can never be a popular method, as it does not provide for the drainage of the tears into the nose as nature has intended. The excess tears must then drain over the lid margin.

3. The third group attempts to drain the tears into the nose by a short-circuiting operation into the middle meatus of the nose. This was first popularized by West, who described his operation in 1910, before the American Ophthalmological Society. He makes a large window in the lateral wall of the nose, opposite the position occupied by the middle and upper third of the nasolacrymal duct. While this is the operation of choice with many operators, the precision of the operation has been greatly reduced by the lack of knowledge of the exact position of the stricture and the size and location of the sac. We know of no way in which this knowledge may be gained accurately, except by getting a visual image of the passageway, or of the portion of it above this stricture, in its relation to the surrounding structures. This work was begun, therefore, with the object in mind of producing such a picture by means of the roentgen ray.

We have, in the past fourteen months, studied about sixty obstructed and normal passageways. Our method of procedure has been to undertake the usual routine of attempting to syringe solutions by way of the puncta through the sac and duct into the nose. Following this, the passageways are injected with oil and bismuth and roentgenograms are made in several positions which will be described later.

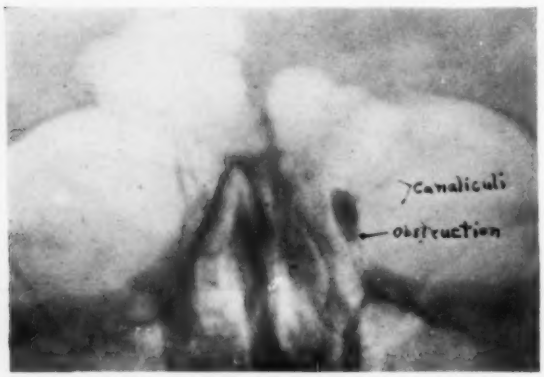


FIG. 1. Before operation. Shows an obstruction at the junction of the sac and duct. The sac shows a moderate degree of dilatation. Both canaliculi are well filled.

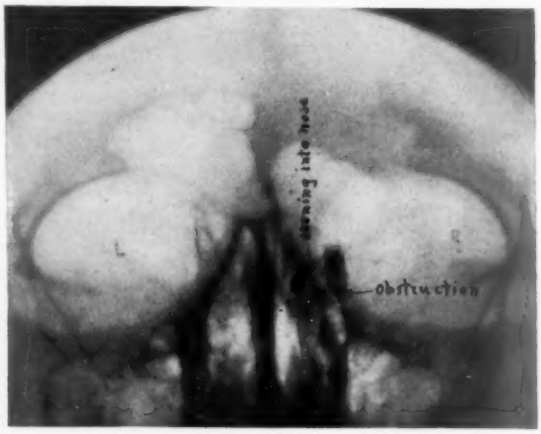


FIG. 2. Following operation in which an opening was made into the nose. Shows bismuth passing into the nose.

To give the technique of injection in detail: A few drops of a 2 per cent cocaine solution are dropped on the lower cul-de-sac and any mucus or pus which may be in the sac is expressed by pressure. If desired, the punctum to be used in the injection may be dilated slightly but under no circumstances do we slit the canaliculus. The passages are then syringed out with normal saline to which a few drops of 1–1,000 epinephrin solution have been added. Following this, the passages are injected with Beck's bismuth and oil paste. For the injection we use an ordinary 2 c.c. all-glass Luer syringe and a No. 19 lacrymal needle. In the progress of our work we have found it desirable, in certain cases, to obstruct the punctum which is not being used for the bismuth injection. For this purpose, a medium-sized common pin is put in the punctum selected. If it is found necessary to warm the bismuth paste, this should be accomplished by the use of dry heat, for if steam comes in contact with the bismuth, the oil will be

precipitated out and difficulty will be experienced in getting an even flow through the small caliber needle. Less than 1 c.c. will be necessary to inject the unobstructed passageway, while about ½ c.c. will suffice in those passageways with obstruction. In trying to locate the sac, relative to the intranasal structures, we have found that the placing of a small silver rider over the anterior end of the middle turbinate, just

FIG. 3. Before operation. Shows an obstruction in the upper portion of the duct, with a dilatation of the sac above this.

below its attachment to the lateral nasal wall, is of considerable value. Recently we have outlined the position of the entire anterior end of the middle turbinate with a strip of bismuth, which is easily applied by using a long lacrymal needle. Our lateral plate will then show how much of the unobstructed passage lies above or below the root of the turbinate and also whether it is in front of or behind the turbinate. We have not used the marker in all our cases, but we feel it to be a procedure of value. The patient complains of little or no discomfort from the injection of the bismuth.

METHOD OF ROENTGEN-RAY EXAMINATION

This has all been carried out with the duplitized-film double-screen technique. The exposures were made in a number of different positions. The positions which we have found to be the most valuable are the following:

1. The Waters-Waldron sinus position with the chin resting on the plate and the nose raised slightly from the plate. The objection to this position is that frequently the nasolacrymal duct will lie over the maxilla and thus will be partly obscured. To obviate this difficulty we have used the following position.

FIG. 4. Shows normal sac, duct and canaliculi as shown in the postero-anterior view. This also shows a metal rider over the root of the middle turbinate on the opposite side.

2. In this case we have used the same position, except that we have rotated the head toward the side which has been injected with the bismuth paste. The amount of rotation used is about 10°. This will frequently throw the injected sac over the ethmoidal cells and will show the injected sac standing out in bold relief.

3. In this position we have the patient's forehead and nose touching the plate, the plate being inclined about 15°. Here also

the sac will frequently be seen over the ethmoidal sinuses.

4. A plate made in the lateral position. It is important in this examination to see that the head is in a true lateral position. The vertical ray is directed perpendicular to the plate at a point about the anterior portion of the lower border of the orbit. It is often desirable to make the plates stereoscopically.

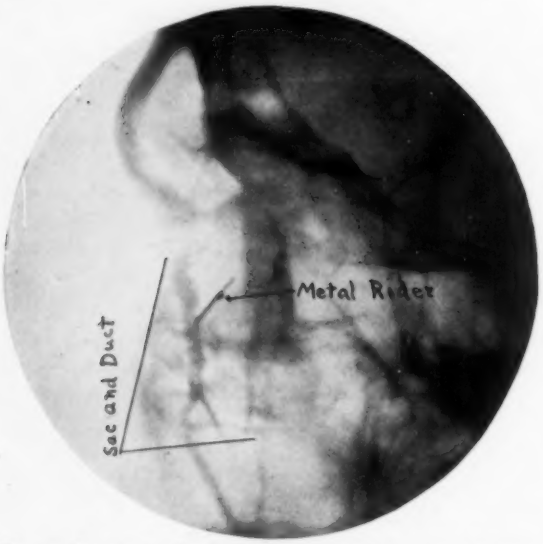


FIG. 5. Same as Fig. 4, but showing the normal structures as seen in the lateral view.

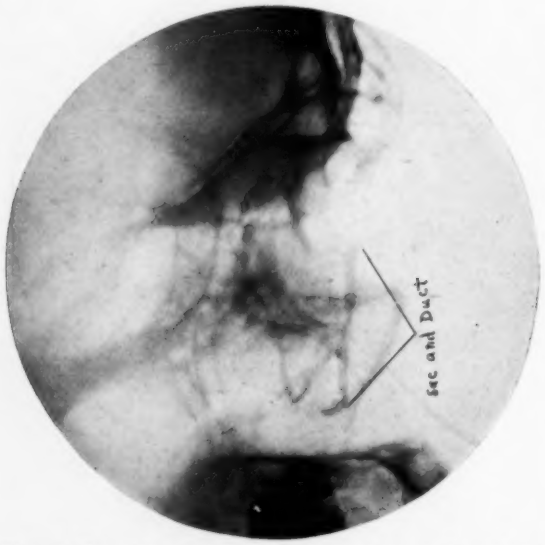


FIG. 6. Normal case showing sac and duct well outlined.

In a number of our early cases we have inserted a specially-cut film in the nose for use in the lateral position, but this has never proven as successful as with the larger film on the outside.

In the study of plates of patients complaining of no symptoms referable to this region, and therefore classed as normal cases, a number of abnormalities have been found. Absence of one of the puncta is occasionally found, and in one case, multiple puncta were discovered. The sac is ordinarily joined to the nasolacrymal duct with an end-to-end union, but we have found in several cases a side-to-side joining. The outline of the sac and duct, as studied from the roentgenograms of several of these cases, is seen to be extremely irregular and tortuous, and it is easy to see from the study of these plates why difficulty is often experienced in passing probes on such cases.

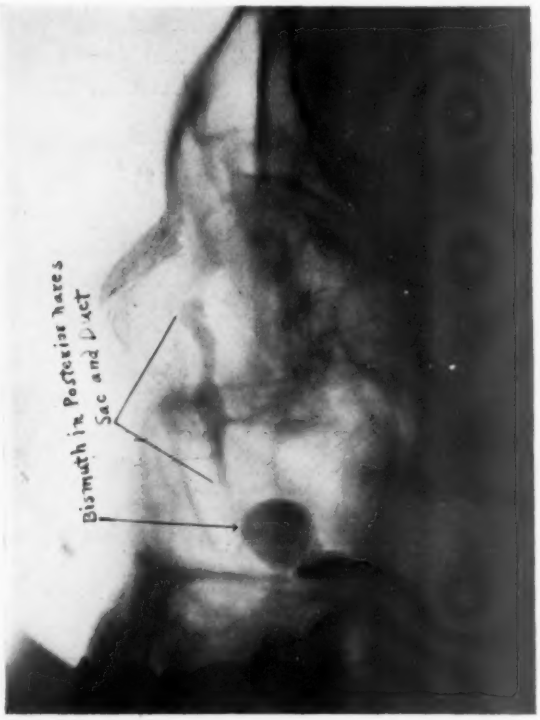


FIG. 7. Normal case showing irregular outline, which is frequently seen as a normal variation. Also, a large collection of bismuth is seen in the posterior nares.

In this series a number of negroes have been examined, and in practically every case, the nasolacrymal passageway has been wider and straighter than in the white race. Fernandez has arrived at a

similar conclusion, basing it on anatomic studies.

In the diseased or obstructed passageways, we have found two extremes: First, a very marked dilatation above the point of obstruction, very similar to the dilatation seen in the esophagus above a marked obstruction; second, the passageway may be very small or practically obliterated, due to repeated abscess formation with resulting scar tissue. Many of the intermediate forms between these two extremes have been found. One of these cases presented a fistula running from the sac into the ethmoid labyrinth, and one into the soft tissues of the face.

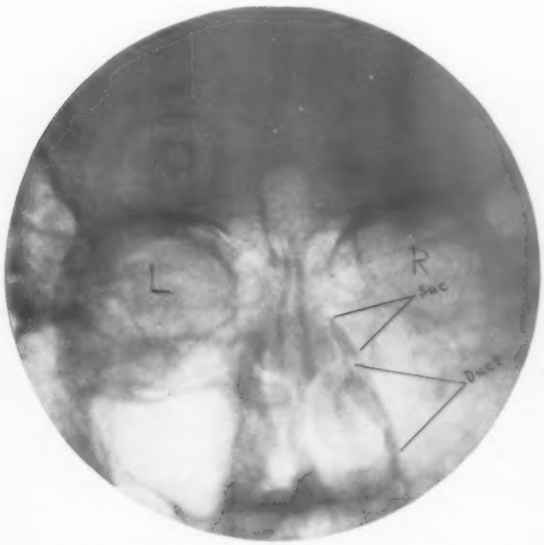


FIG. 8. Normal case shows side-to-side joining of sac and duct.

FIG. 10. Lateral view of same case as Fig. 9.

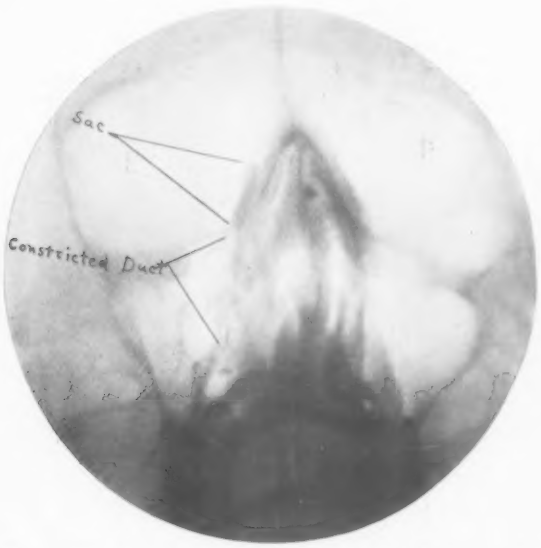


FIG. 9. Shows a very narrow constricted duct, causing partial obstruction. Postero-anterior view.

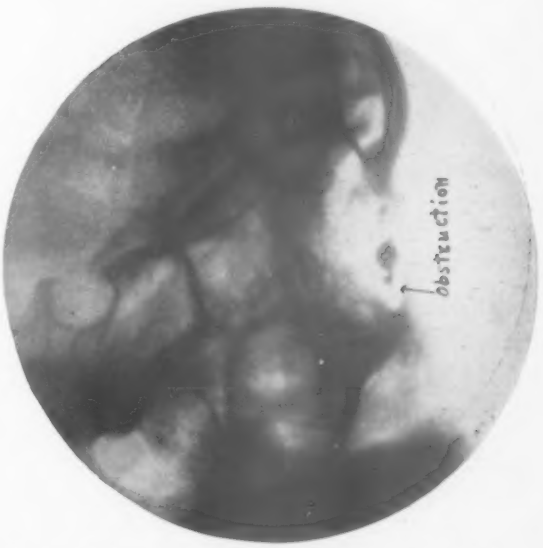


FIG. 11. Shows an obstruction at the junction of the sac and duct with another constriction above this. Patient complained of repeated abscess formation in right sac and tearing on this side.

In this series there are 20 cases of complete obstruction of the nasolacrymal passageways. We have been interested to study the *x*-ray plates on these to determine the possible association of sinus

disease with lacrymal obstruction. The data developed would seem to be quite significant. First, it should be emphasized that these patients have tearing as their chief complaint, and have not complained of sinus trouble, and as far as the sinuses are concerned, might at first thought, be classed as cases taken at random. To state our findings: 60 per cent of this obstructed group show on their roentgenograms definite evidence of chronic pathology in the sinuses most intimately associated with the nasolacrymal duct, namely, the maxillary sinuses; while none of them show pathology in the frontal sinuses which are further removed and not in intimate relation with the passageways. The anterior ethmoids were involved in 25 per cent of the cases showing sinus pathology. This series is too small for drawing definite conclusions, but the findings are very striking and lend weight to the theory that chronic sinus disease may often lead to lacrymal obstruction, or vice-versa.

TABLE II
RELATIVE INVOLVEMENT OF THE SINUSES

		Per cent
Pathology in antra	12	100
Pathology in ethmoids	3	25
Pathology in frontals	0	...

TABLE III
COMPARATIVE PATHOLOGY ON OBSTRUCTED AND NON-OBSTRUCTED SIDES

		Per cent
Sinus pathology found	12—	100
Sinus pathology same side as obstruction	9	75
Sinus pathology opposite side from obstruction	3	25

Very important post-operative information can be gained by the use of this method in certain types of cases. First, those cases giving a history of having had the sac removed, which later come in complaining of pus formation in this region. In one case of this series the roentgenogram demonstrated that there was still enough of the sac remaining so that a short-circuiting operation into the nose was considered feasible, while in another case such a small amount of the sac was left that extirpation was the procedure of choice. Second, those cases showing unsatisfactory results following one of the short-circuiting operations. The information to be gained here is, as to whether the

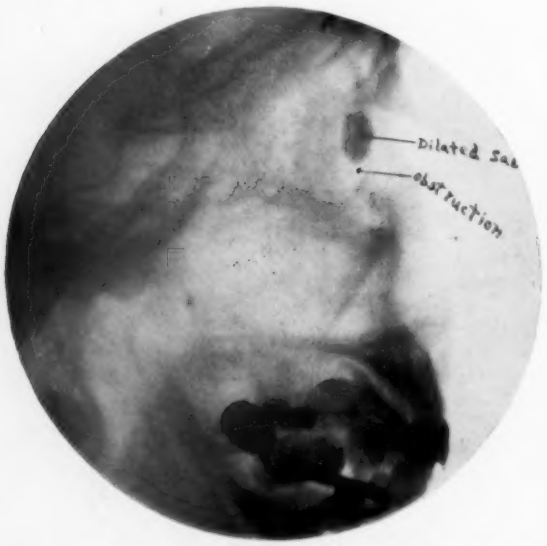


FIG. 12. Before operation showing obstruction at junction of sac and duct with dilatation of the sac.

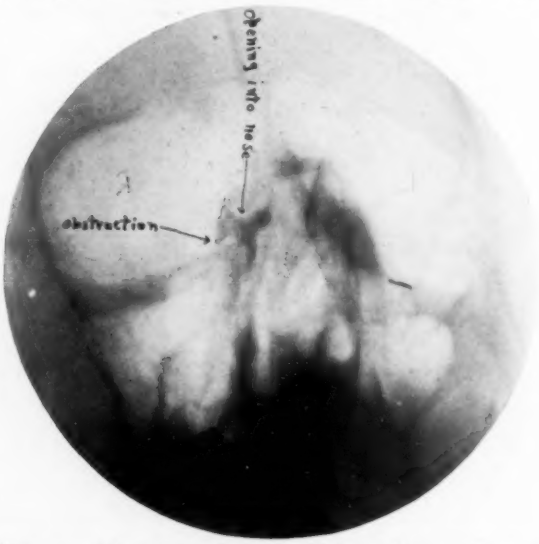


FIG. 13. After operation. Shows bismuth passing into nose through a large window made by the operation.

TABLE I
SINUS INVOLVEMENT IN OBSTRUCTED CASES

		Per cent
Obstructed cases	20—	100
Pathology in sinuses	12—	60
No pathology in sinuses	8	40

artificial opening is functioning, and also as to whether the opening was made near enough to the point of obstruction to obtain dependent drainage.

CASE REPORTS

CASE I (No. 22,907). Female. Complained of tears falling over the cheek, on the

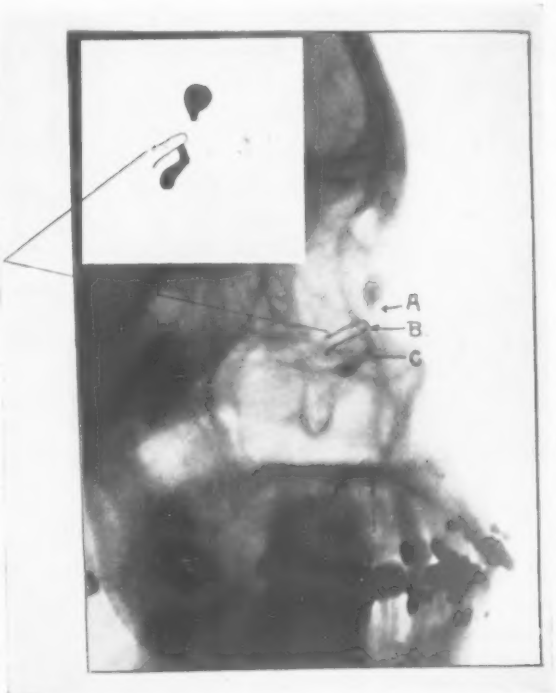


FIG. 14. Shows obstruction in sac at (A). Metal rider (B) and stripe of bismuth on anterior end of middle turbinate (C).

right side. This has been inflamed at times, and the sac often contained pus, but it has been controlled by argyrol. Has never had abscesses of the sac. The nose is negative. *X*-ray of the sinuses is also negative. Operation in March, 1912, in which a new opening was made into the nose from the obstructed sac as shown in the *x*-ray examination.

Figure 1 shows the opening to be very small and not placed so as to get dependent drainage. As the patient's symptoms were not entirely relieved, a second operation was done and a larger opening made, following which the patient has remained free of symptoms to date (Fig. 2).

CASE II (No. 22,017). Female. Complained of tearing from the left eye over the cheek, for the last six years. Says she can press pus out of the sac. She was examined in the office and found to have an acute abscess. This was excised under gas anesthetic. Following this the acute abscess cleared up. The patient was later *x*-rayed and an obstruction rather high up in the duct was seen, with considerable dilatation of the sac above this. The operation was performed Sept. 30, 1921, with excellent results following, and the patient has had no further trouble with this eye.

CONCLUSIONS

From this preliminary report, embracing the study of sixty cases of normal and obstructed passageways, and also the study of ten of these cases following operation, certain conclusions can be noted.

1. In cases of complete obstruction this method gives valuable data in deciding what type of operation is to be performed, and if an opening into the nose is decided upon, it shows the point where dependent drainage may best be accomplished.

2. In these cases of partial obstruction it is easy to see what type of sac and duct is present and if these are suitable for probing, or if an intranasal operation is necessary.

3. Valuable post-operative information may be gained in those cases where a new opening has been made and the case is progressing poorly.

4. By the roentgenogram one can confirm or disprove that the sac has been completely removed at the time of the operation.

5. The condition of the paranasal sinuses, especially the antra and ethmoids, can be noted as the possible cause of the obstruction.

DISCUSSION

DR. BORZELL. I would like to ask Dr. Doub whether a study has been made of both sides and how favorably they compare with each other.

DR. DOUB. I did not put much data in the paper. I might say we studied both sides in a large number of instances, and found there was no regularity in the development of the two sides. We could not say that because one side might be regular, the other side would be the same. Unfortunately, we have no slides showing both sides.

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TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY
LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922
Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

THE CALDWELL LECTURE

It is with much pleasure that the president-elect, Dr. Wm. H. Stewart, announces that Dr. Wm. Duane of the Harvard Medical School will deliver the Caldwell lecture at Los Angeles. The title of the lecture will be announced at a later date. All those who are acquainted with Dr. Duane's work are pleased that he has consented to act in this capacity, and those of us who will attend the meeting have something extraordinary to look forward to, as his contributions are of more than usual interest to the science of roentgenology.

LONDON LETTER

DEAR SIR:

The idea of establishing through the medium of your Journal an "Entente Cordial" between America, France, and Britain will meet with hearty approval on this side of the Atlantic. During the war the intercourse, unfortunately only of short duration and at irregular intervals, between American and British radiologists has clearly established the fact that we have everything in common, and hardly any differences of view; if any, none so serious that they cannot be overcome in friendly discussions. Perhaps the only point on which our views seriously conflict is that of nomenclature. The time is opportune for a reconsideration of that serious question. We on this side resolutely set our faces against the attempt to "roentgenize" everything appertaining to our art, and it is in our mind that many of our colleagues on the other side of the Atlantic view the matter in the same way.

This subject alone would be worthy of the activities of a joint committee from our two Societies, and I feel sure that a happy solution to our difficulties and differences in nomenclature would be found. The committee could work in collaboration with the British Engineering Standards Association.

The matter is more urgent than it appears at first glance. We on our side are energetically working out the education question for both medical and non-medical workers in radiology, and if the students we attract are to have a clear conception of the importance of the work, then we must at once determine in what language they are to be taught the technicalities of their subject.

The proposal just put forward is that the American Society of Radiologists and the Societies on this side should each appoint a representative nomenclature committee. When opportunity offers either could send a representative to meet one or other committee in consultation, and something definite could soon be achieved. These committees could as an extension of their work, act as an information bureau, to which all radiologists visiting either country might apply for guidance and help. Another extension of the work would be for the committee to arrange for the exchange of students, and short courses of lectures from radiologists who might be visiting either country. It would give us

great pleasure at any time to arrange for a course of lectures in London, by any eminent radiologist who would not be overburdened by such work while on holiday.

In Britain, educational work in radiology and electrotherapy has made decided progress. During the early years of the war, it was realized that something had to be done to put these subjects on a sound scientific basis, if, in the future, we were to hold our own in progress and technical development. The war found us collectively unprepared, though individually we were fortunately able to do enough to keep the work going.

A small committee appointed to discuss the matter quickly resolved itself into the British Association for the advancement of Radiology and Physiotherapy. The late Sir James Mackenzie Davidson was the first president, and he greatly helped the onward progress of the movement by his ready sympathy and financial support.

The University of Cambridge was approached with a view of establishing a diploma in "Radiology and Electrology." With commendable forethought and enterprise the authorities proceeded to discuss the possibilities, and after several meetings with representatives of the B.A.R.P. it was arranged that the University should grant a diploma (*a*) after examination, (*b*) by dissertation, carrying with it the right to use the letters D.M.R. and E.

Active teaching was arranged for at Cambridge and in London. The courses consist of systematic lectures, practical demonstrations, and at least six months' clinical and technical instruction at a recognized hospital.

A great deal might be written about arrangements and the scope of the instruction given. Much of that will follow in later letters, but the chief points have been dealt with very briefly in order to give our colleagues in America some idea of the activities of the radiologists, electrotherapists, and diagnosticians in this country.

The diploma at Cambridge is open to qualified men and women all over the world, who can satisfy the committee at Cambridge of their suitability. The diploma by dissertation can be obtained by candidates who have held a recognized post for a sufficient period of time. The dissertation is considered by the committee and sent out to two referees for their opinion. It is with feelings of pleasure that I can state that already several distinguished American radiologists have sent in dissertations, and have been awarded the diploma. Surely this is propaganda work of the highest order.

The University of Liverpool also grants a diploma after examination. In the able hands of Dr. Thurstan Holland the teaching is of the best, and Liverpool is certain to be a "focus spot" for American radiologists.

The non-medical assistant has not been neglected. A society—The Society of Radiographers—has been founded. It, in its turn, arranges for the training of assistants in *x*-ray and electrical departments. A certificate is given on the candidate satisfying the court of examiners. This entitles the worker to use the letters M.S.R.; i.e., member of the Society of Radiographers.

Already the stimulating influence of this society is being felt, and it is evident that the medical side of the work must be kept at a high standard if it is not to be eclipsed by the routine work of the radiographer. It is also evident that the establishment of these two societies working in complete sympathy will go a long way towards removing any antagonism that may have existed, and that to preserve the distinction between a medical side and a technical side will lead in the end to the advancement of the subjects. A highly trained medical man is unsuitable in the purely technical routine of the work, while a highly trained technical man is equally out of place as a medical radiologist. One must be complementary to the other, and both are essential; each can excel in his own branch.

Yet if real progress is to follow upon our efforts, something further requires to be done. The diploma at Cambridge should automatically become a degree in radiology. This would necessitate the provision of more extensive teaching and the endowment of a chair at the University. The teaching would require to be carried out at several recognized centers throughout the country. An extension of the system

would be to provide suitable centers throughout the Empire, and the recognition of teaching schools in other countries, particularly in America. The practical value of such an extensive scheme would soon become evident, and it would be a very efficient factor in co-ordinating the teaching of the subjects in America and Britain. The endowment of research would be a logical outcome of the working of the scheme, and a central Institute of Radiology could be established.

Steps are on foot which we earnestly trust may eventuate in the formation of a nucleus of a large institution; indeed it may be said that the nucleus already exists, for the generous action of Lady Davidson has already placed in our hands the library and a number of pieces of experimental apparatus, transparencies, etc., the property of the late Sir James Mackenzie Davidson. It is the intention of a committee dealing with the matter to establish at the Institute of the future a Mackenzie Davidson Museum and Library. And later, if possible, one or more Mackenzie Davidson Chairs.

It is thus evident that we on this side of the Atlantic are alive to the needs of our specialties, and if we have not so far succeeded in raising a pile of buildings worthy of the subjects, we have at least made an effort to do so, and will eventually succeed.

In conclusion let me thank you for the honor you have done me in asking for a London letter for publication in your Journal. It will give me great pleasure to send you items of news of interest to your readers, and in order that the interest may be maintained, I have invited my colleague, Dr. Hector A. Colwell, to collaborate with me in my efforts. I feel sure that he will be able to add greatly to the value of all our communications.

Yours sincerely,

ROBERT KNOX.

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